POWER

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The Economy of Aggregation

WHEN a community starts, each of its inhabitants gets his water supply where best he can. As the density of its population increases and their demands grow in extent and complexity, a common water supply is installed. Instead of having to pump or carry water from more or less sanitary springs or wells, the bath or basin is filled by the turning of a tap.

The settlement becomes a city and a period of drought reminds it that the present supply will not eternally fulfill its growing needs. There follows a systematic study of available sources, the best methods of connecting them with the city and the most effective plan of distribution, of financing and executing the work and distributing the service.

The United States is in the provincial stage so far as many of the products and services that make up the lives of its citizens are concerned. We are just beginning to take an intelligent, systematic account of our fuel resources. Our light supply got away from the old oaken bucket stage when the candle and lamp gave way to gas and the incandescent light. Power is now on tap for a multitude of domestic and small industrial uses, and even large manufacturing enterprises frequently find it cheaper to purchase power from a central source than to generate it themselves.

And in this respect we are coming to the stage where an intensive study is being made of the present and probable demands of the country for light and power and of the available sources of supply, that they may be built into a consistent, mutually supportive system, realizing the surety and economies of aggregation and standardization and bringing to bear upon the all-important problem of our power supply the benefits of systematic, scientific organization and ingenuity upon the broadest scope for the most effective and economical development and utilization of our power resources.

The day of the village shoemaker and local butcher is gone. They are replaced not by shoe factories and slaughter houses, but by combinations of shoe companies and by packing interests with ramifications in every town. There is efficiency and economy in such organization, and under proper control it is the best way to conduct the big business of a big nation.

German Steam Boiler Designed for 850 Pounds Pressure

By BRUNO SCHAPIRA*

IN THE course of the last twenty years, engineers in Germany, as well as in other countries, have come to realize the necessity of greatly increasing steam pressures if the steam-power station of small or moderate size is to compete successfully and permanently with gas and oil engines. Raising the steam pressure has particularly interesting possibilities in power plants where some of the steam is exhausted or bled for heating purposes. The higher the back pressure the greater is the relative advantage of high initial pressure.

The firm A. Borsig, in Berlin, is now constructing for its own use a steam-power station designed to carry a gage pressure of about 850 lb. per sq.in. at the engine throttle. The 850-hp. engine will operate with a back pressure of 140 lb. and drive an air compressor.

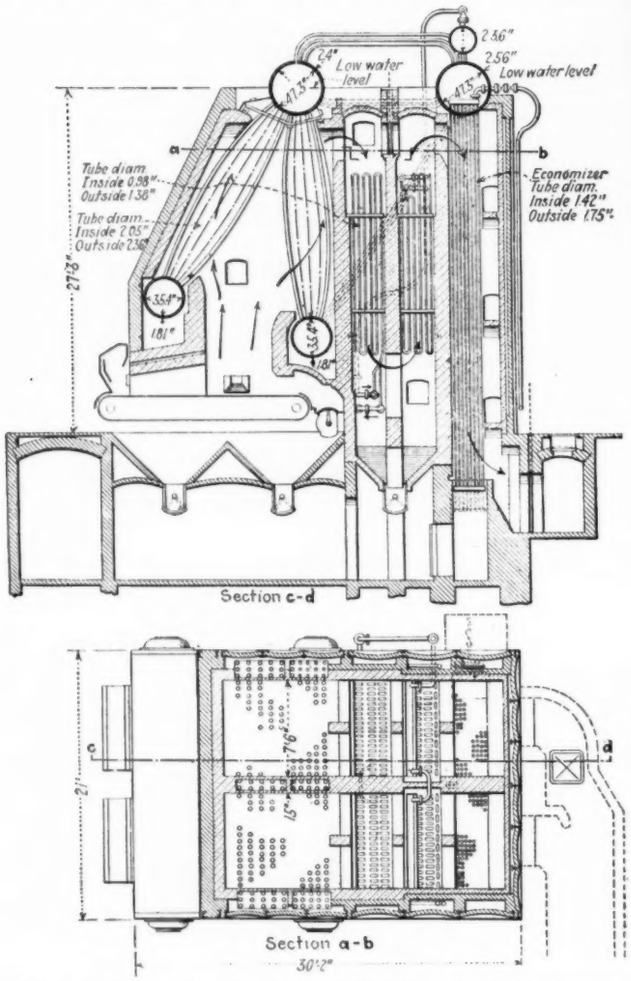

FIG. 1—CROSS-SECTIONS OF BOILER AND ECONOMIZER

The exhaust steam will flow into a heat accumulator, which in turn will supply the steam hammers of the shop. The boiler is designed to generate 15,500 lb. of steam an hour.

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Fig. 1 shows the design of the boiler plant. The drums are forged from one piece of metal without welded or riveted joints. Fig. 2 is a shop view of one of these drums. To relieve any internal stresses, the drums are annealed after forging. Special plates, shown in Fig. 1, are provided to protect the upper drum from all contact with hot flue gases. There is suffi-

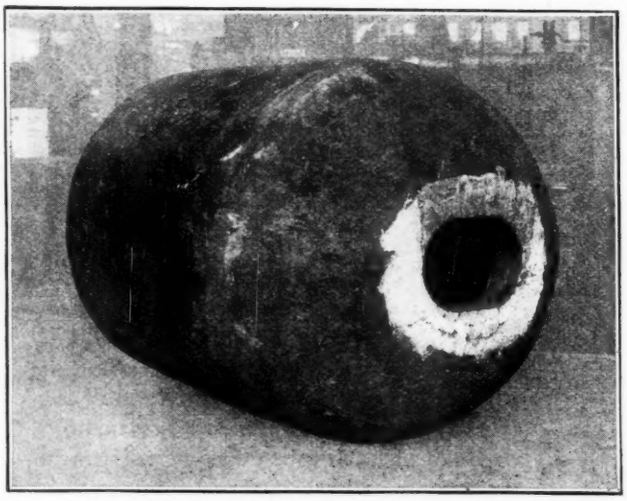


FIG. 2—SHOP VIEW OF BOILER DRUM

cient space between these plates and the drum to permit inspection of the tube connections at the drum while the boiler is in service. Sufficient clearance is allowed in the holes in the plate through which the tubes pass to allow normal heat expansion of the tubes but to prevent any vibration that might cause leakage. As a result of this protection the temperature at all points of the drum will be practically the same as that of the saturated steam.

Drums Protected from High Temperatures

The temperature in the isolating space underneath the upper drum is only 570 deg. F. This protection is important, because large differences of temperature would set up abnormal stress in the thick drums that are necessary with the pressure carried. Aside from the normal stress due to the pressure, the only possible additional stress is that due to expanding in the tubes while cold, but this can never be injurious. The protection of the drum from contact with the hot flue gases permits the use of a special steel, which in turn will make it possible to raise the pressure above the normal working point of 850 lb. The material used shows its greatest strength around 540 deg. F. The construction here shown for high-pressure boilers is based on tests which Wilhelm Schmidt, the well-known constructor of superheaters and steam engines, has been making since 1910, for the purpose of determining the most practical and useful method of constructing and operating boilers and engines at high pressures. Working in connection with O. H. Hartmann, Mr. Schmidt suc-

cessfully constructed reciprocating engines of very high thermal efficiency.

For a long time scientific men as well as practical engineers, were skeptical as to the successful application of high-pressure steam up to 850 lb. This feeling was probably due to the fact that a perfect engine, with complete adiabatic expansion, exhausting at a 95 per cent vacuum, shows a possible theoretical gain of only about 12 per cent if the pressure is raised from 215 lb. to 725 lb., the initial steam temperature in both cases being 750 deg.

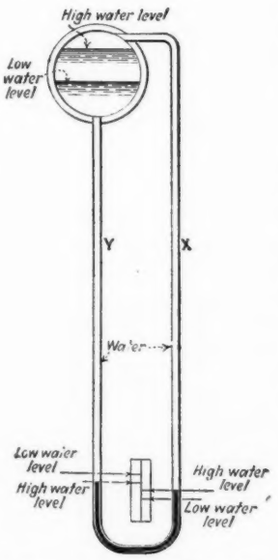


FIG. 3—REMOTE-READING WATER-LEVEL GAGE

There were also doubts as to the practicability of constructing and operating boilers at these pressures. In order to show that there is no practical difficulty in producing high - pressure steam, W. Schmidt constructed in 1910 a test boiler having 10.8 sq.ft. of grate surface, and 744 sq.ft. of heating surface, including the superheater. When firing 13,500-B.t.u. coal, the boiler produced about 1,500 lb. of steam per hour at a pressure of 850 lb. and a total temperature of 840 deg. F.

In the large new boiler shown in Fig. 1 the water tubes are placed so that the prolongation of the tube ends meets at a point on the upper drum shell. This makes it possible to clean or remove the tubes through an opening on the top.

The high temperature of saturated steam at the pressure carried makes it impossible to obtain a low flue-gas temperature without economizer surface. For this reason the last section of the boiler, consisting of the vertical tubes shown at the right, is designed as an integral economizer, which lowers the flue temperature to about 430 deg. F.

Integral Economizer Used

Some engineers have feared that steel-tube economizers like that shown would be subject to corrosion. Nothing prevents putting cast-iron economizers of the usual construction for low pressures behind the boiler. If the economizer is fed by a centrifugal pump there is only the feed-water pump to be regulated, which takes the heated feed water from the cast-iron economizer and delivers it to the high-pressure steel-tube economizer section. This arrangement makes it easy to degasify the feed water. As the upper drums are protected from the flue gases, large variations in the water level are possible, and in this way sufficient space is obtained for large fluctuations in the feed.

The small test boiler was equipped with the usual fittings. The packing places of all fittings subjected to high pressure were made of nickel. Much difficulty was experienced with bursting gage glasses. For this reason the remote-reading water-level gage shown in Fig. 3 was constructed. It consists of a U-shaped tube, the lower portion of which is made of glass and contains mercury. The arm *X* connects with the steam space of the upper drum above the highest water level, while

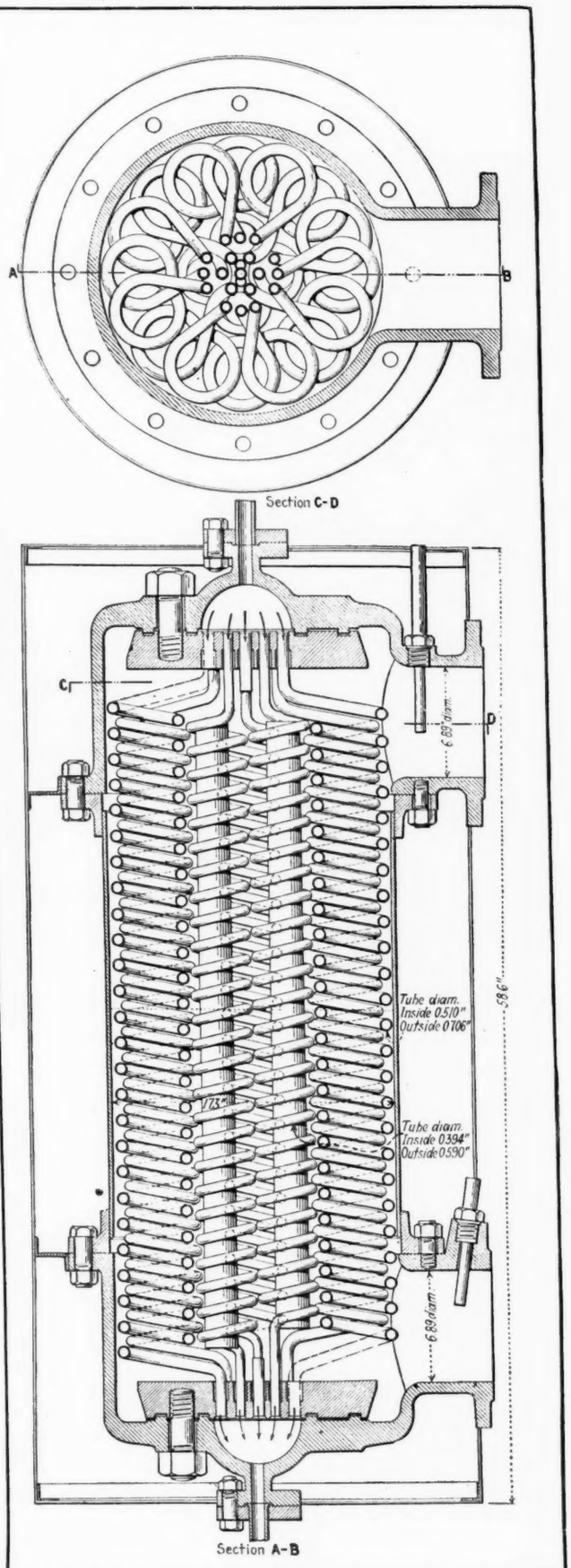


FIG. 4—REHEATER OPERATED BY STEAM FROM BOILER

the arm *Y* is connected with the bottom of the drum. The condensation of steam in *X* keeps it full of water up to the point of connection to the drum, thus maintaining a constant hydrostatic head on this arm. The head on the arm *Y* is determined by the amount the water level lies below the drum connection of the arm *X*. The manometer scale at the bottom can therefore be graduated to read the difference in level of the two mercury columns in terms of water level in the upper drum. It is true that the movement of the mercury is small, necessitating fairly close reading of the manometer. This disadvantage, however, is more than compensated for by the fact that the gage glass keeps cool and is not subjected to temperature strains.

Leakage Problem Not Serious

No difficulties were experienced in making tight joints between the tubes of the test boiler and the drums. No leaks developed, nor were there other interruptions during operation. On several occasions slight leaks were observed in the economizer. These were easily remedied. The feed temperature ranged from 140 deg. F. to 175. After three years of service the grate of the boiler was enlarged to 15.5 sq.ft., and by forced service and good draft the boiler output was raised to 2,960 lb. an hour. No harm resulted from this forcing. To date this boiler has operated for from 15,000 to 16,000 hours, and has been started at least 1,500 times. In this connection it is interesting to note that the feed water used was unusually dirty.

Equal success was experienced in the test made with high-pressure reciprocating engines. By using intermediate superheating and very great expansion in several steps, Schmidt found how to obtain practically complete expansion without condensation. For the intermediate superheating, saturated steam at boiler pressure and a temperature of 530 deg. was used. It was thereby possible to attain steam temperatures ranging from 430 to 480 deg. F. The steam-heated reheater used is shown in Fig. 4.

By using a quadruple-expansion high-pressure steam engine, the following results were obtained: With 780 lb. initial pressure, 95 per cent vacuum, 815 deg. F. initial steam temperature, 480 deg. steam temperature between the second and third cylinders, and 430 deg. between the third and fourth cylinders, a steam consumption (including intermediate superheating) of 5.8 lb. per hp.-hr. was obtained. This result, compared with the performance of the best piston steam engine today, corresponds to a heat saving of 22 per cent.

Summary of Results

The practical results obtained may be outlined as follows:

The production and use of high-pressure steam has been practically tested; high-pressure steam boilers and high-pressure steam engines can be constructed economically and operated with safety.

When operating condensing, the steam consumption per indicated horsepower-hour is about 5.8 lb., as against 8.8 lb. for an operating pressure ranging from 215 to 285 lb. per sq.in., the corresponding coal consumption per indicated horsepower being about 0.8 lb. as against 1.1 to 1.2 lb. for the lower pressure.

The combination of power generation and heating, with the help of high-pressure steam engines, is in common use, as the back pressure, with such great initial pressure, is not a matter of so much importance as with steam engines operating at normal throttle pressures. The back pressure may, if necessary, be chosen as great as the initial pressure now commonly used. In this way exhaust steam may be used for processes for which it was formerly necessary to supply live steam direct from the boilers.

Existing power stations can also be changed over into high-pressure stations, either by altering the existing condensing steam engine for the use of high-pressure steam, or by putting a high-pressure plant ahead of the existing engines.

Condenser Air Leakage Measured at Vacuum Pump Discharge

By B. C. Sprague

Efficiency Engineering Dept., West Penn Power Company

Air leakage is a more serious factor in hot weather. This practical and simple device may be of great assistance in maintaining condenser efficiency when the circulating water is at summer temperature.

THE arrival of warmer weather, with the resulting higher circulating-water temperatures, will again cause power-plant operators to consider the problem of obtaining the best possible heat transfer in their surface condensers. It is now generally realized that in a great many cases large temperature differences between the steam and circulating water are results of excessive air leakage. The work of keeping this leakage to a minimum is greatly facilitated if some means for measuring it is provided.

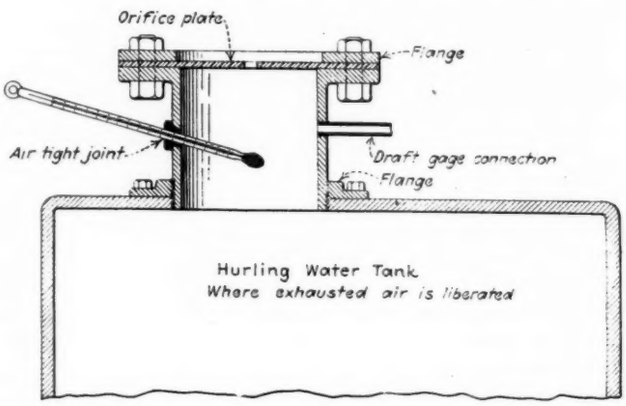


FIG. 1—ORIFICE AND DRAFT GAGE APPLIED TO HURLING-WATER TANK

Where hydraulic vacuum pumps are used, it has been customary to measure the volume of the air discharged from the hurling-water tank by means of an air bell. One large power plant now employs a gas meter for this purpose. Anemometers may be 60 per cent or more in error, unless corrected by factors as obtained from tests under operating conditions. The writer found that the pulsations of flow of the air also produced a large error in the reading of an anemometer. Since anemometer measurements are found unreliable, a method of using an orifice in a similar capacity was devised. It is possible by this means for every plant

equipped with a hurling-water tank, to obtain a continuous record of the air leakage.

Two iron plates about 0.05 in. thick are cut and drilled for inserting between a pair of 3-in. or larger pipe flanges, as in Fig. 1. In the center of one plate, a half-inch and in the other a one-inch hole is drilled. Although all burrs should be removed, the edges of the holes are preferably left square. The plate corresponding to the amount of air to be measured is inserted in the pair of flanges connected to the hurling-water tank by means of a short nipple as shown. The nipple should be drilled and tapped for inserting a thermometer and for making connection to a draft gage.

How to Determine the Air Discharged

For indicating the leakage an inclined oil draft gage is best, unless a recording draft gage is preferred. The following formula is used for determining the air discharged:

$$Q = 0.57\ d^2\ \sqrt{H\ T}$$

where H is the inches of water shown by the draft gage, T is the absolute temperature Fahrenheit of the air discharged, d is the diameter of the orifice in inches, and Q is the cubic feet of air discharged per minute. The curves in Figs. 2 and 3 show the volume discharged by each of the two orifices with an air temperature of 70 deg. F. Ordinary changes in temperature have little effect on the volume of escaping air and may be neglected unless extreme accuracy is desired. Note that H in the formula is expressed in inches, but h in the curves is in tenths of an inch. Example: One-inch orifice, temperature 60 deg. at one-inch water pressure gives 13 cu.ft. air from the formula. Substituting h as ten-tenths in Fig. 3, we obtain 13 cu.ft. per minute.

Before making measurements, the hurling-water tank must be gone over and made nearly airtight. If provided with an overflow pipe, this may be plugged or a U-shaped trap installed in the line. It is surprising how tight it is possible to make concrete tanks; one having several openings has been made so that it requires 30 minutes for the pressure to fall from 1.5 to 1.0 in. of water when the tank is sealed.

Sometimes a large amount of air will be found leaking into the vacuum pump. This reduces the volume of air and vapor drawn from the condenser and affects the vacuum almost as much as would the same amount of leakage in the condenser. This air can be easily measured by running the vacuum pump with the valve to the condenser closed.

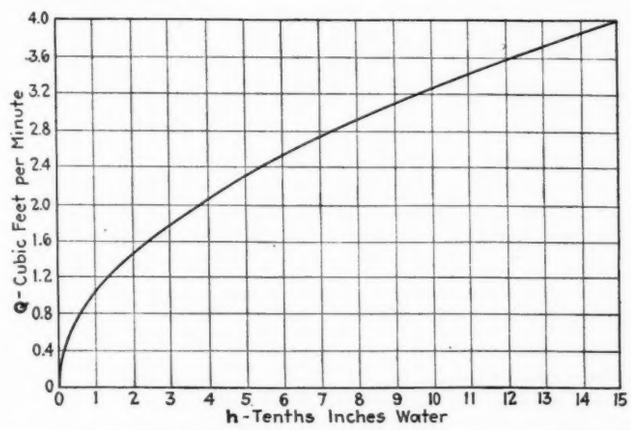


FIG. 2—AIR DISCHARGED AT 70 DEG. THROUGH ONE-HALF INCH ORIFICE

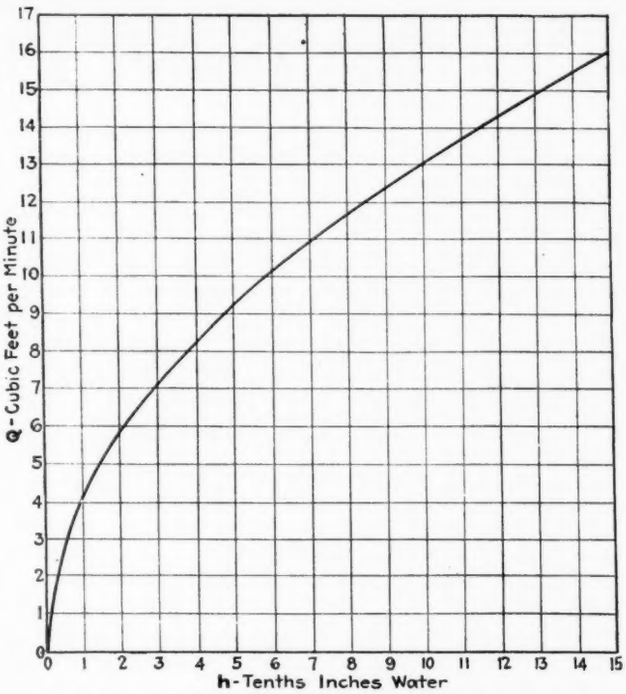


FIG. 3—ONE-INCH ORIFICE MEASURES 70 DEG. AIR DISCHARGED

If the air leakage is found to be much greater at small than large loads, leaks should be looked for in the turbine casing. The recording gage is of especial value in this connection, since it will show all variations of air leakage with load. If at any time an excessive air leakage is recorded, an analysis of the other records will probably show what changes are responsible for it.

To avoid accidents due to low water in boilers the following suggestions should be kept in mind constantly: Before starting up in the morning, make sure that the gage glass shows the water to be at the right height. Blow down the water column next, and see that the water promptly returns to its proper level when the blow cock on the column is closed again. Try the gage cocks also, and see that the water level as indicated by them agrees with that shown in the glass. If the water is low, do not introduce feed water, and if the feed pump (or injector) is running, stop it immediately. If the boiler is one of a battery, shut off the feed pipe running to it, and close the stop valve in the steam pipe leading from the affected boiler to the steam main. As soon as these things have been done, cover the fire with a thick layer of ashes. If ashes are not handy or if there is but a small quantity of them available, shovel in fresh coal, taking care to cover the fire at every point until the boiler is effectively screened from the hot fuel on the grates. It is far better to bury the fire in this way than to haul it out of the furnace, because a great deal of heat would be given off to the boiler before the hauling could be completed. Remember that the boiler has shown its ability to withstand the stress under which it was operating when the water was found to be low, and proceed on the theory that the thing to do is to reduce this stress *gradually* and without any sudden change of any kind whatever.—*Travelers Standard.*

The Power Plant of Today*

By C. F. HIRSHFELD
Chief of Research Dept., Detroit Edison Company

THE author reviews the present tendencies in large plant design, employing higher pressures together with regenerative and reheating cycles, and questions whether there is sound reason behind these innovations or whether we are blindly following the lead of Europe or certain prominent American designers. He also discusses powdered coal versus stokers and is of the opinion that the chief point in favor of the former is not so much the increased efficiency attainable as the ability to utilize variable grades of coal.

AT THE present time a great many almost revolutionary power-plant designs are being tried in this country. It is probable that to a certain extent we are following styles set in Europe, where conditions are entirely different, and that in some cases we are more or less blindly following the lead of certain outstanding American designers. I feel that it is highly desirable to emphasize the danger latent in thus following the leader without giving serious thought to the real, underlying economic considerations involved.

Most of the recent power-plant developments have been along the lines of increased thermal economy. In our effort to attain higher thermal economy we have raised the steam pressures and talked about raising them still further; and we are considering the use of pulverized fuel instead of stokers in the boiler room. In addition, we have adopted two new steam cycles, one called the regenerative cycle, and another which may be called the Ferranti, or reheating cycle. With respect to steam pressures we have heard in this country that they have plants operating in Europe, very successfully, with pressures approaching 500 lb. These plants may be doing all that is claimed for them, but as yet I have been unable to find that they are. Therefore, we are not justified in designing and installing such plants in this country merely on the assumption that they are operating successfully in Europe.

At the present time there are two distinctly different schools of thought with respect to higher-pressure plants. One assumes it proper to design and build a plant having an initial boiler pressure of about 550 lb. per sq.in. The steam is passed through one turbine unit, preferably of the cross-compound or tandem-compound type. The high-pressure end receives steam at about 550 lb. pressure. with a temperature of about 700 to 725 deg. F., and exhausts it through a reheater into the low-pressure cylinder. There are several such stations being built in this country.

The other school assumes that it is not economical to build that kind of a station, that the proper thing to do is to start with a boiler pressure of 1,000 or 1,200 lb., with a steam temperature of about 700 to 725 deg. F., and to expand this high-pressure steam through a small turbine and then carry it at a pressure of about 300 lb. to a turbine of the type now being used. In this way practically all the experimental work is confined to 1,200-lb. boilers and small 1,200-lb. turbines. Assurances have been given that there is nothing very experimental about such boilers and turbines, but none of them have been built yet, and I feel that there are many things to be solved both in their construction and operation.

By studying the question first on the theoretical side, it will be discovered that as the pressure is increased from 200 to 300 lb. there is theoretically possible a large thermal gain. As the pressure is increased from 300 to 400 lb. the possible gain decreases, and from 400 to 500 lb. the theoretically possible gain decreases still further, so that each increment of 100 lb. brings a smaller possible improvement. Really, the situation is basically worse than this fact would indicate, for in the actual apparatus, as the pressure is increased, certain steam conditions are brought about during expansion which tend to decrease the actual performance of the machine with respect to what is theoretically possible.

There are developing two schools with respect to how this loss, which must necessarily occur, shall be partly prevented. One school believes that after the steam has expanded part way through the system, it should be reheated. After the steam has expanded part way, some of it begins to condense and the water resulting from condensation decreases the hydraulic efficiency of the turbine. This school takes the steam out of the turbine at the time when it gets to a condition deemed proper for such purpose, takes it back to the boiler room or to a separately fired reheater, which is really a superheater, and puts more heat into it, thus once more superheating it. The steam then returns to the turbine. That, theoretically, is an attempt to produce what has been called the Ferranti cycle.

The other school does not believe that the complication and expense of reheating is warranted and says that the right thing to do is to take the steam which has become so wet that it affects seriously the hydraulic efficiency of the turbine, put it through some sort of a separator, remove the water and put it back into the turbine.

This solution is simple and cheap, but no one yet knows from experience whether it is the right solution or not.

During this evolution there has come into use what theoretically is called the regenerative cycle, in which the condensate from the turbine is passed through a series of feed-water heaters, in which it is heated by steam bled from different stages of the turbine from which it has just emerged as condensate. So the condensate, starting at hotwell temperature, passes back along the turbine toward the high-pressure end, through a series of heaters, and into each of those heaters is bled the amount of steam required to heat the condensate to within a few degrees of the temperature of the bled steam. With an infinite number of such feed-water heaters the feed water could be brought up to boiler temperature. In theory this heating could be done in

*An address delivered before the National District Heating Association, Cedar Point, Ohio, June 20, 1923.

very small temperature steps and an efficiency could be obtained far in excess of anything that we may ever hope to approach by present methods. But no one could afford to pay for an infinite number of heaters or their connections, and it seems probable that three stages of such feed-water heating will be the answer in plants with high load factors, and two stages in plants with low load factors. That, then, is our approximation to the regenerative cycle.

All these developments have been made for the avowed purpose of attaining higher thermal efficiency, and so far as known, all involve increased investment. With respect to the newer developments little is generally known about the extent of the increase in investment. Such figures as I have lead me to believe that a great many engineers in this country are not inclined to give adequate thought to the increased cost of this more efficient plant when they consider the desirability of adopting the higher pressures and the greater complications, such as reheating and stage heating. For base-load plants greater investment can be justified, for in these plants it is expected that the turbines will be operated for all that can be got out of them; that is, every possible hour of the twenty-four and every possible day in the year.

Careful Study of Conditions Is Necessary

It will be recognized that the foregoing is no argument for adopting such pressures or such methods in the ordinary low-load-factor power plant. When asked to consider the adoption of pressures much above 300 lb. or anything involving reheating or stage heating beyond two, or possibly three, stages, make a very careful study of three things: First, the load factor; second, how long that load factor may be maintained; and third, the increment of investment required to get the high thermal efficiency which is being advocated.

From a study to be published soon, in which was obtained the actual kilowatt-hour output from some 260 turbines scattered all over this country, starting with the year that they were put in and running through to date, it was discovered that it took on the average three years to reach the maximum kilowatt-hour output per year from each turbine. From the time when that was attained the output immediately fell off, and by the time the turbine was ten years old it was practically a stand-by unit.

In our plants we have had turbines with averages of five years. If the war had not intervened, one plant that I know of would have had four sets of turbines with average lives of five years. Now when the designer learns that the daily load factor is 74, 64 or 45 per cent, whatever it may be, he immediately says: "That is good for ten or fifteen years," and he predicates the use of the invested capital on those figures. Usually he is wrong. Therefore, the engineer who is going to operate the plant or the man who must make good to the stockholders, should put upon the designer the kind of a check just indicated. Many are failing to do this because of enthusiasm for getting something new and better than the other fellow with which to establish a new record. They are failing to consider how much they can earn on a dollar, how long they will be able to earn it and whether they will have earned enough in addition when that time is over to retire that dollar.

In the boiler room what seemed to be practically the end of the stoker development was reached some seven or eight years ago, and then came brand new lines, both in chain grates and underfeeds, and this new development is not yet ended. Along toward the end of this period, during which the stoker is receiving what might be called its latest development, the pulverized-fuel method of firing for boiler rooms received its recent impetus. Then came the announcements that Milwaukee, after experimenting with powdered coal in a comparatively small station for a number of years, had adopted it for the Lakeside station, that the new St. Louis station being laid out as one of the best, had adopted it, and quite recently Detroit had adopted it for a 300,000-kw. station and that Duquesne, West Penn, Rochester, and others had decided to use it.

Why Pulverized-Fuel Firing Is More Efficient than Stoker Firing

It is a fact that pulverized-fuel firing in most cases will give a higher boiler efficiency than stoker firing, and the reasons are quite obvious. No one has yet found out how to operate a stoker without a fairly large amount of combustible in the refuse. It is comparatively easy to operate a pulverized-fuel-fired furnace with a reasonably small amount of combustible in the refuse, and this means some thermal saving. It is difficult to operate stokers, with the best coals, at a carbon-dioxide content of the flue gases above somewhere between 14 and 15 per cent, and through the 24 hours it is generally below this figure, although in some of the better stations with fairly steady loads it is maintained quite close to that point. With the pulverized-fuel furnace, if well designed and well controlled, operation can be maintained with a considerably higher percentage of CO_2 than is averaged in stoker practice, so that a saving can be effected here. That is about all the question amounts to, and the possible savings from such sources can be figured easily.

In addition a further saving may be made if there are long periods during which the boiler must be banked. A certain amount of coal must be burned when banking a stoker-fired boiler, whereas with a pulverized-fuel-fired boiler the fuel supply is shut off, although some coal must be burned to heat up the setting again when starting

Roughly, a stoker installation, with the best of coals and properly handled, with present types of stokers, can give boiler-room efficiencies within somewhere between 2 and 5 points of what an exactly corresponding boiler room fired with pulverized fuel will give, and whether it be the 2 or the 5 per cent will depend upon a number of considerations, such as the load factors, the kind of ash and the coal, the type of equipment and so on.

Stoker-Fired Plant Less Expensive

But as far as I have been able to determine, a pulverized-fuel-fired plant which is equally spacious, safe, easy to handle and equally flexible, will cost more than the stoker-fired plant. Then there are the preparation costs, which as yet are not down to the place where they should be and are a serious offset in dollars and cents to the coal saving obtained by virtue of the higher thermal efficiency.

It should be pointed out that until a few years ago, we adhered strictly to certain types of furnace-wall design and to certain elevations through the plant. We have not been willing to give the stoker designer a free hand with respect to the equipment which he was to supply and the way in which it was to be set with reference to the boiler. The furnace volume was limited to a comparatively small space. When the pulverized-fuel advocates came along, they started out doing much the

same thing, but it quickly developed that to get results they had to have a certain furnace volume, air-cooled walls, water screens and so on. In most of our modern pulverized-fuel plants all these things are being put in, and nobody knows what would happen if the stoker man were given the same latitude.

It is known that if he were given a hollow furnace wall through which he could draw the air for his stoker, so that it is preheated, if the stoker or the furnace did not burn up with the higher air temperatures, a material increase in efficiency would be obtained. Figures are reported running as high as 5 per cent, but whether they are right or not, it is easy to calculate 2 or 3 per cent.

Room for Both Kinds of Equipment

So stoker development is not yet over. The stoker has not been given the chance that we are now giving pulverized fuel. It would appear that there is going to be a place for both kinds of firing equipment.

As a note of warning, do not adopt pulverized fuel because some of the big fellows have adopted it, for reasons that probably have not been explained or for reasons that may not be basically sound. In the case of the new Detroit plant the calculated increased thermal efficiency was not the governing factor at all. Some of our difficulties in Detroit came from inability to obtain a uniform coal supply. In times like the present the coal producers will meet the specifications set for them, but let fuel get scarce, and coal will be supplied that the stokers used by the company are not adequately suited to handle. It was felt that the pulverized-fuel equipment would take care of such variations better than our stokers, and that in this and other indirect ways a pulverized-fuel installation would be justified.

The foregoing case is cited to emphasize the fact that the increased thermal efficiency promised by the pulverized-fuel advocate is only a small part of the story. It is necessary to consider all of the increased costs that may go with it and also what could be done if the stoker were given a proper chance.

It has been learned by experience at Milwaukee, with a certain type of equipment, that for pulverized-fuel burning a certain cubical content is necessary per unit of capacity developed, that refractories must occupy certain positions with respect to the flame and not be in other positions, that certain things must be done to take care of the small amount of ash or refuse collecting in the furnace, and in a metropolitan district means will have to be devised for taking care of that part of the refuse passing out the stack. These are a few of the things that should be pitted against the enthusiasm of the pulverized-fuel advocate.

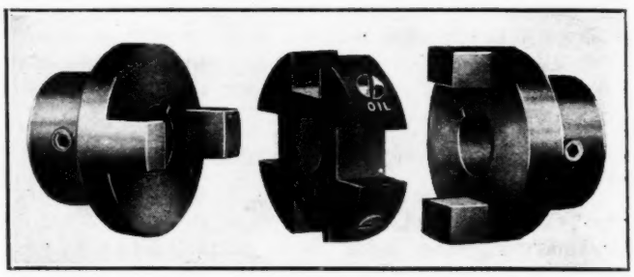
A Kilowatt Hour per Pound of Coal

In a brief way the foregoing is the story of the power plant as it is today. As to what it amounts to, thermally, a kilowatt-hour per pound of good coal is in sight, and if the cost is warranted, a plant can be constructed that will do this. In 1913, 1914 and 1915 about 20,000 B.t.u. per kilowatt-hour was good performance. There were few plants in the country that did it. There are plants now doing in the neighborhood of 18,000 B.t.u. per kilowatt-hour. The figure in sight is nearer 14,000 B.t.u. So strides in the ability to get thermal results have been made, but the cost of doing it has not yet been discovered. We do not yet know how far we are warranted in going toward that obtainable 14,000 B.t.u. per kw.-hr., but if we have to, we can do it.

The problem is to find the economic balance between the present 18,000 and the possible future 14,000. It is easy to be persuaded that a little more money should be spent to get a little better thermal results, but before doing so in any particular case, look over the plant records and see what use has been made of existing equipment, and do not be too optimistic with respect to useful life when making the decision.

Higgins Flexible Coupling

A flexible coupling made specifically for direct motor drive, that will allow parallel misalignment of $\frac{1}{8}$ in. between the driving and driven shafts, an angular misalignment of 3 or 4 deg. and an end play of $\frac{1}{8}$ in., has been patented by Eugene Higgins, of Jackson, Mich., and is being made by the Tomkins-Johnson Co., of that city. As shown in the illustration, it is made of two duplicate members keyed to the ends of the shafts and a middle member slotted to receive driving lugs pro-



FLEXIBLE COUPLING FOR DIRECT MOTOR DRIVE

jecting from the shaft members. The lugs make a loose fit in the slots, and with the space between the shaft pieces slightly greater than the thickness of the middle member, the latter is free to float endwise. It is made of fibrous material compressed under high pressure and heat to a dense, tough substance in order to withstand the service.

Lubrication is effected from a central reservoir made by drilling a hole through the center of the middle member and capping both ends. Two small radial holes, closed by capscrews, admit the oil to the reservoir and allow the air to escape. One filling lasts for several months, as the oil by capillary attraction seeps slowly through the material to the wearing surface. The middle member is renewable and the coupling is made in sizes for 1- to $3\frac{1}{2}$-in. shafts.

A New British Zeolite

An announcement from England tells of a new zeolite (exchange water-softening material) that is said to have a number of advantages. The new material is named "Permutit B." The rapidity of its action is said to be such that the material is exhausted in a period ranging from three to six hours. The fact that regeneration can be accomplished in one hour makes possible the continuous use of a single unit if sufficient soft-water storage is provided for one hour's requirements.

The new "Permutit B" is a natural product chemically treated. Among the claims made for it are immunity to free carbonic acid and a reduction in the weight of salt required for regeneration.

AERIAL VIEW OF SHAWINIGAN FALLS AND POWER DEVELOPMENT

Hydro-electric Developments of Quebec*

BY JULIAN C. SMITH

THE province of Quebec comprises that vast stretch of territory lying east of the Ottawa River and north of the United States boundary line, bounded on the north by Hudson Strait, on the west by Hudson Bay and on the east by Labrador. It is 2,000 miles in width from north to south, and 1,350 miles from east to west, having an area of 706,804 square miles, or almost 25 per cent of that of the United States. The northern section is for the most part uninhabited, but the southwestern portion, lying along the lower part of the Ottawa and St. Lawrence Rivers and extending south to the American border and east of the Saguenay River, is an important and rapidly growing industrial section.

If we average the figures for the various stations throughout the province, we arrive at an estimated run-off for the whole province of eighteen inches a year. Substituting this figure for the total precipitation, we obtain a total of 88.7 million kilowatts of continuous power, and allowing an efficiency of conversion of 60 per cent from the stream to the distribution center, there remains 53 million kilowatts of continuous power as the maximum possible hydro-electric power that could be produced if during all seasons every drop of water that ran off the 500,000 square miles of territory considered were converted into hydro-electric power. This is, of course, an impossible condition.

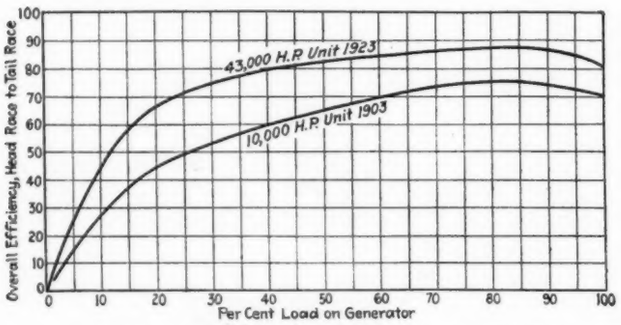
Combining the sources of lost energy enumerated, we may assume that not more than 25 per cent of the 53 millions of kilowatts of energy contained in the total run-off could be converted into electric energy, and therefore that the actual potential electric energy of the province of Quebec is approximately thirteen to fifteen millions of continuous kilowatts.

In the present state of the art of the development and distribution of hydro-electric power, only those sites near industrial centers and at which water power exists in considerable quantities are capable of being developed commercially. The theoretical available quantity of fifteen to eighteen million kilowatts of continuous power must therefore be very considerably reduced in estimating the quantity of power that is actually adaptable to industrial purposes. From recent surveys of the water powers of the province and considering only those rivers on which water power is available in such quantities and in such locations as could be economically developed either now or in the near future, the quantity of actually available water power in the province is estimated at approximately 5¼ million kilowatts of continuous power, of which some 800,000 kw. has now been developed and utilized. There remains, therefore, in the province of Quebec as available commercial water power about 4.5 million kilowatts of continuous power, or about 12 million horsepower at 50 per cent load factor.

It must be borne in mind that no industry is able to make continuous use of the power that it requires, and that therefore no power company supplying power for

* From a paper presented at the recent meeting of the A.S.M.E. at Montreal.

industrial purposes is called upon to supply the total amount of contracted power all day every day in the year. The term "load factor" is used as a measure of the duration of use of power and is defined as average power divided by peak power. The load factors of the various industrial loads in Quebec differ considerably.



COMPARATIVE EFFICIENCIES OF TURBINES, 1903 AND 1923

For instance, paper mills operate at a load factor of between 85 and 75 per cent, averaging more nearly 75 per cent; carbide and electrochemical plants operate at 85 to 90 per cent; cement mills at 80 to 90 per cent; and asbestos and mining industries at 45 per cent load factor. The load factor of a hydro-electric station supplying various industrial establishments and providing power and lighting service to communities will obviously be the average of the combined load factors of the various loads. Such a plant will therefore not require to use continuously the flow of its water that will produce maximum output. Provided sufficient water-storage capacity exists, the surplus energy that the normal flow of the river could produce may be stored in the form of water, but otherwise a certain portion of the available energy—which might be very great at certain seasons in the year—must be allowed to run to waste. In estimating the amount of energy available for industrial uses from the flow of the river at a given head, due consideration must therefore always be given to the storage capacity of the watershed and to the amount of regulation of flow that is possible with full utilization of the storage capacity.

Early Water-Power Developments

The earliest water-power developments in the province were constructed by the French to grind the grain of their dependents. These little grist mills were in existence as early as 1650 and were almost always developed by the construction of a small canal which carried the water to an overshot or undershot wheel, where the heads used varied from about five or six feet up to ten or fifteen

The first real hydro-electric development was the Montmorency plant, near the mouth of the Montmorency River, seven miles below Quebec, built in 1895 and having an installed capacity of five 600-kw. generators.

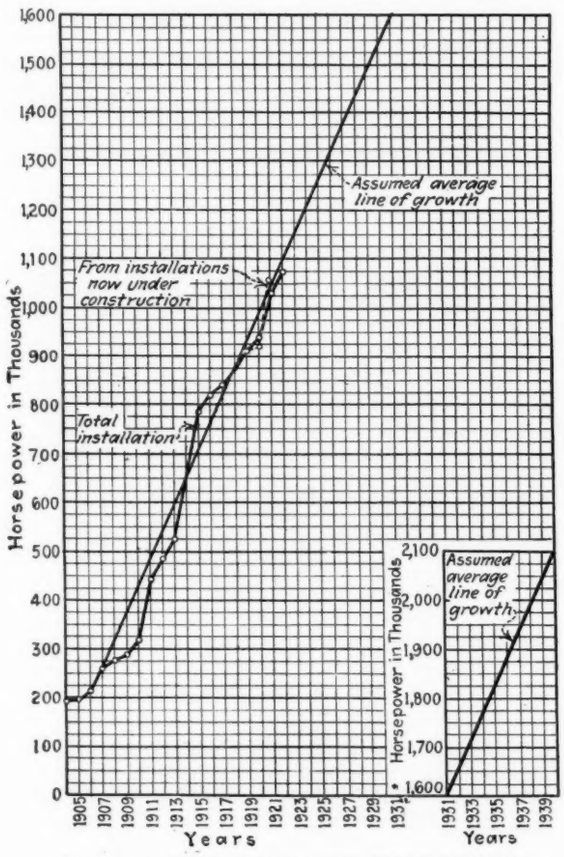
This was followed in 1897 by the St. Narcisse plant, on the Bariscan River, with an output of 750 kw., which was transmitted to Three Rivers over a two-phase 12,000-volt transmission line 18 miles long. This was the first high-tension line in the British Empire.

The Chambly plant, on the Richelieu River, 17 miles from Montreal, was built in 1898 with four 2,000-kva. machines, the output of which was transmitted to Montreal at 25,000 volts three-phase; and in the same year the Lachine Rapids plant was put into operation with a maximum output of 10,000 kw. at certain times of the year only.

The principal water powers now in operation in the province of Quebec may be divided as follows: Powers on the Ottawa River; powers on the St. Lawrence River; powers on the St. Maurice River; powers on the Saguenay River and its tributaries in the vicinity of Chicoutimi; and powers on the south side of the St. Lawrence River, particularly on the St. Francis River and its tributaries.

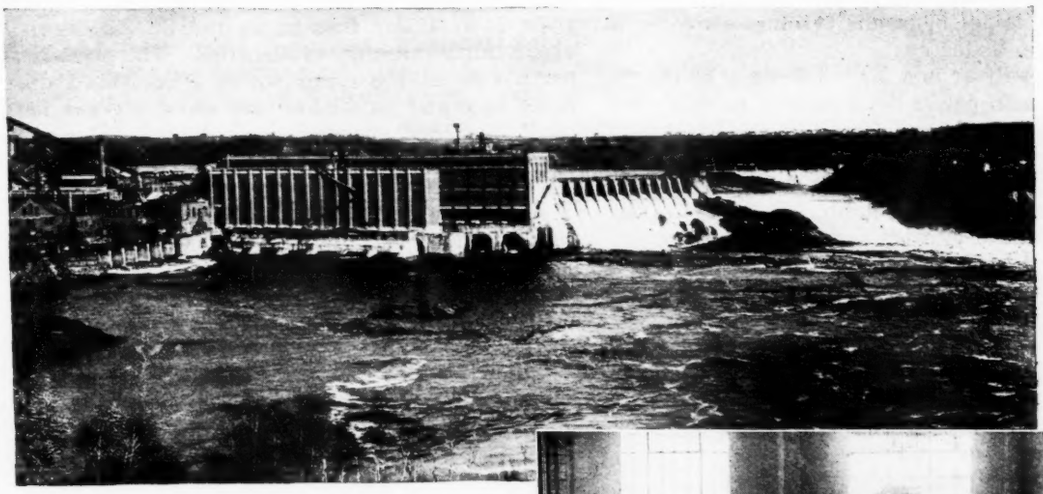
The two great developments existing today in this province are at Cedar Rapids, on the St. Lawrence River thirty miles west of Montreal, and on the St. Maurice River at Shawinigan Falls and Grand Mere. The third great power, which ultimately may eclipse these, is now being constructed on the Saguenay River just below the outlet of Lake St. John.

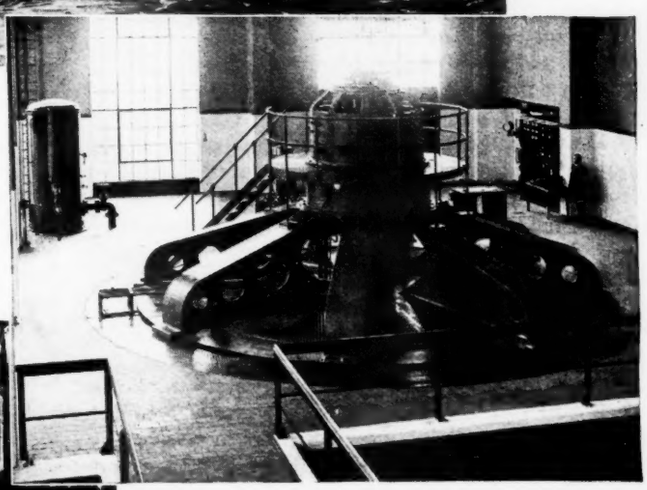
In addition to the developments that generate electricity for use in public-utility service or for industrial service in the neighborhood of power developments, there are a large number supplying power for grinding wood. These latter are widely scattered throughout the



GROWTH OF WATER POWER IN PROVINCE OF QUEBEC

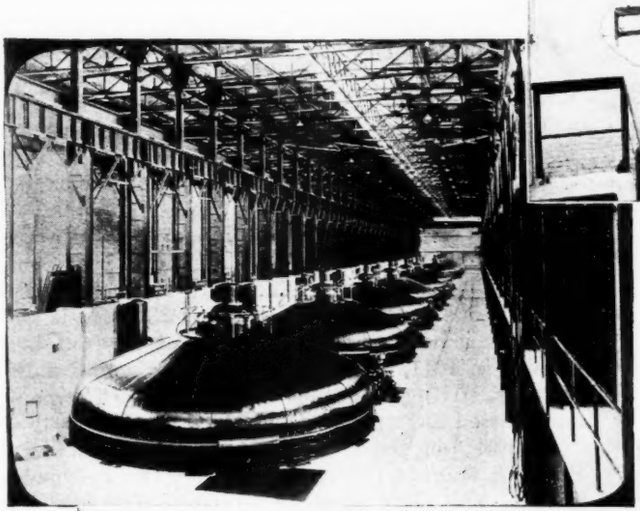
province, most of them having been built prior to 1910. The total amount of hydraulic power used directly for this purpose in the province, has been stated by the Water Power Branch to be 162,825 hp. With the advent of the vertical turbine and the increase in the size of electrical generating units it became in many cases more economical to develop the power in the form of electricity to be transmitted to pulp and paper mills built in favorable positions rather than to locate the mills at the





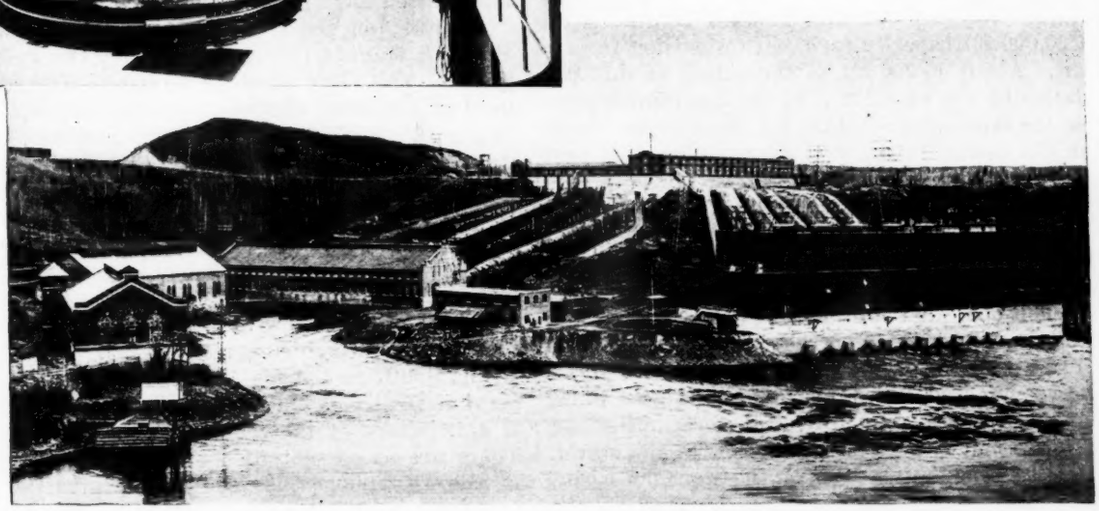
Above: Laurentide Power Development at Grand 'Mere, Que.

Right: 43,000 Hp. Unit Recently Installed at Shawinigan.



Left: Interior of Cedar Rapids Power House.

Below: Shawinigan Water & Power Company's Development.



SOME PROMINENT WATER POWER PLANTS IN QUEBEC

site of the power development. The amount of hydro-electric power so used is stated to be 157,367 hp., making a total of 320,192 hp. of hydraulic turbines employed in the pulp and paper industry.

The St. Maurice River is a large tributary of the St. Lawrence. The main power developments on this river are at Shawinigan Falls and Grand Mere, 21 and 27 miles respectively, north of the City of Three Rivers. The plants of the Shawinigan Water & Power Co. are at Shawinigan Falls, where the natural formation of the falls furnishes an ideal location for power development. The available head is about 150 ft., and after the dams and headworks had been constructed, the first two units in power house No. 1, of 5,000 hp. capacity each, were put into commission in 1902. In 1909 the capacity of the station was 58,500 hp., all the generators being of the horizontal type.

Power house No. 2, with two horizontal units of 18,700 hp. capacity each, was in operation in 1911. Later, three additional units of similar size were installed. The output of this station now totals 136,500 hp., the latest unit put in commission in October, 1922, being of the vertical type and having a rating of 43,000 hp. The water is carried to the turbine of the latest unit through a tunnel cut through the solid rock, while in all earlier installations of both power houses, concrete-covered steel penstocks were used. At present the combined generating capacity of the two stations is 195,000 hp., with provision for two more 43,000 units.

The Northern Aluminum Co. at Shawinigan Falls operates two power plants generating direct current for use in its own works. The total capacity of these plants is about 40,000 hp., the units being of the horizontal type, with each turbine driving two direct-current generators. There are six units in No. 1 power house and five in No. 2 power house, the average working head being about 145 feet.

Paper Mill Takes Large Block of Power

At Grand Mere, six miles above Shawinigan Falls, is the plant of the Laurentide Power Co. There is a head of about 84 ft., and work on the power development was completed in 1916. The power house is built on the dam, and at present there are installed eight vertical units of 20,000 hp. capacity each, with provision for one more unit. About 40,000 hp. of the output of this station is taken by the paper mill of the Laurentide company, and the remainder is sold to the Shawinigan Water & Power Co. and is distributed over the lines of that company. These high-voltage transmission lines radiate from Shawinigan Falls, there being six lines to Montreal, 85 miles long, two lines 90 miles to Quebec, and two crossing the St. Lawrence at Three Rivers, serving the asbestos district and extending to Sherbrooke.

The efficient operation at all times of the year of these hydro-electric developments on the St. Maurice River is largely due to the existence of the Gouin Dam at La Loutre, two hundred miles above Shawinigan Falls. This dam is owned by the provincial government and creates the second largest storage basin in the world. It and the three regulating dams on the Manouan River, a tributary of the St. Maurice, are operated by the government so as to be of the greatest benefit to all the users of the water of the river.

The Montreal Light, Heat & Power Consolidated, which serves most of the City of Montreal and surrounding districts, besides taking a large amount of power from the Shawinigan company, also owns and operates four hydro-electric plants. The largest of these is at Cedar Rapids, on the St. Lawrence River about thirty miles above Montreal. The plant is on the north side of the river, where a rock-filled dike two miles long and paralleling the shore gives a headrace canal one thousand feet wide whose lower end terminates with the power house. The power house forms the dam joining the dike to the main bank. The turbines operate under a head of 32 ft., and the present installation consists of twelve 12,500-hp. and two 13,200-hp. generators with four 1,500-hp. waterwheel-driven exciter units. All units are of the vertical type. There is provision for four more 13,200-hp. machines and two exciter units, which will be installed in the near future, bringing the output of the station to the total of 229,200 hp. Part of the power from this plant is transmitted to Montreal at 66,000 volts on a steel-tower transmission line, and part is transmitted at 110,000 volts 48 miles to Massena, N. Y., where it is used in the works of the Aluminum company.

Montreal Supplied from Several Plants

The Montreal Light, Heat & Power Co. also operates the Soulanges plant, which is on the St. Lawrence River about thirty miles above Montreal, with a head of 50 ft. and an output of 15,000 hp.; the Lachine plant at the Lachine Rapids, six miles above Montreal, on the St. Lawrence, with a head of 14 ft. and twelve units giving an output of 13,000 hp.; and the Chambly plant on the Richelieu River, with an installation of eight units and a total output of 31,000 horsepower.

The Quebec New England Hydro-electric Corporation, formerly the Montreal Public Service Corporation, distributes power in the City of Montreal, which is generated at its hydro-electric plant at St. Timothee, on the south side of the St. Lawrence River, about thirty miles above Montreal. Use has been made of a portion of the old Besuharnois Canal, which has been enlarged, and the drop due to the Coteau and Cedar Rapids is utilized to obtain a head of 50 ft. The plant was put in commission in 1911, and four 5,300-hp. horizontal units are installed, giving an output of 21,000 hp. The power is transmitted to Montreal at 44,000 volts.

At Hull, on the Ottawa River, the Ottawa & Hull Power & Manufacturing Co. operates two hydro-electric plants. The older plant of 10,000-hp. capacity is now used as a reserve, depending on water conditions, while in the No. 2 plant there are two 10,000-hp. horizontal units with the turbines operating under a head of 40 ft. This plant began operations in 1919. A third unit is being added and there is provision for a fourth before the ultimate output is obtained. The company sells its product to the municipal system of the City of Ottawa. The E. B. Eddy Co., in Hull, in its own power house at this location, also generates 10,000 hp. which is used in its large manufacturing plant near by.

The Southern Canada Power Co. has a hydro-electric plant at Drummondville, on the St. Francis River, which is a tributary of the St. Lawrence on the south side. There are at present in operation two 3,360-hp. units in the Drummondville plant, with provision for the installation of two more units of similar size. The available head is 32 ft. This power is fed into the company's transmission system, which covers the part of the province known as the Eastern Townships.

There are several power developments on the various tributaries of the St. Lawrence below the City of

Quebec. The Quebec Railway, Light, Heat & Power Co., which supplies part of the load of Quebec City and district, has two power stations on the Montmorency River. This river flows into the St. Lawrence seven miles below Quebec City, and the Montmorency plant makes use of 208 ft. of the 270 ft. drop at the Montmorency Falls to obtain 4,000 hp. The remaining sixty feet of the total descent of the Falls is utilized below to supply 1,000 hp. to a cotton mill. At Natural Steps, one mile from Montmorency, the power company develops another two thousand horsepower.

The Laurentian Power Co. has a hydro-electric development at Seven Falls, on the St. Anne River, seven miles from its mouth. The St. Anne joins the St. Lawrence at a point about 31 miles below Quebec on the north shore. This is a high-head development, the total drop being 410 ft., and the total output of 20,000 hp. is transmitted to Montmorency and sold to the Quebec Railway, Light, Heat & Power Co.

Large Projects Under Construction

Construction has been started on several new developments during the last twelve months, and the work is being actively carried on at the present time. Of chief importance, due to the size of the undertaking, is the project of the Quebec Development Co. on the Saguenay River. The Saguenay flows into the St. Lawrence on the north shore at a point a little more than 100 miles below Quebec City. Its source is Lake St. John, one hundred miles from its mouth, and the elevation of the lake is about 315 ft. above mean sea level. Its watershed is approximately 30,000 square miles, and the area of the lake varies from 312 square miles at the extreme low water to 402 at flood times. It forms an ideal reservoir for the flow regulation of the Saguenay River. About 300 ft. of the total drop from Lake St. John to tidewater takes place within 25 miles, and may be concentrated at two points. It is planned to develop 400,000 hp. at the outlet of the lake and 800,000 hp. lower down the river, giving finally a total output of 1,200,000 hp. Work is at present proceeding on the 400,000-hp. plant, which is expected to be delivering power in two or three years.

The Shawinigan Water & Power Co. through the St. Maurice Power Co., a subsidiary company, is developing the water power at the Gres Falls and La Gabelle Rapids on the St. Maurice River, six miles below Shawinigan Falls. Work is now actively proceeding on the construction of the dam. By utilizing the total drop of the rapids and falls, which are close together, a head of 65 ft. will be obtained, and four units of 33,000 hp. each will be installed, giving a maximum output of 132,000 hp. which will be fed into the Shawinigan company's transmission system.

Another new plant upon which construction has begun, is the Calumet Island development of the Ottawa and Hull Power & Manufacturing Co. The site is near the town of Bryson, about forty-eight miles above Ottawa on the Ottawa River. When the dam is completed, a head of 60 ft. will be obtained and units will be installed to give a total output of 60,000 hp. The present plans call for completion before the end of 1924.

The growth of hydraulic and hydro-electric development has been rapid and continuous over the last twenty years. The yearly rate of increase has been about 7 per cent of the installed capacity per year over the last fifteen years, and the present total development is 1,070,000 hp. of hydraulic and electrical capacity combined.

At the present rate of increase the total available amount of hydraulic power, which is estimated at 5.25 million kilowatts or about seven million horsepower, will be developed and utilized in the next 29 years. However, as the increase in development will in general follow the increase in population, it will take considerably less than 29 years to develop all the power now in sight, and a careful study indicates that in twenty to twenty-five years the 7,000,000 hp. will be used up. Furthermore, this time might be materially shortened if any large amount of power were exported from Canada.

A Reduction in Banking Coal*

To determine if it were not possible to improve upon the generally adopted figure of 0.3 lb. of coal per boiler horsepower-hour banked, especially if the banking period is long, a banking test was run on an 8,750-sq.ft. Bigelow-Hornsby boiler equipped with a 9-retort underfeed stoker in the plant of the Rochester Gas & Electric Corporation. This test and others, which have been run since that time covering two-day periods, show that 0.1 lb. of coal per boiler horsepower-hour is sufficient to bank the boiler, supply radiation losses and keep the boiler up to line pressure after the automatic is closed.

The first test covered a period of three days, during which time the unit was handled as an emergency boiler, held with a light fire, cut in twice during the period, run for a couple of hours and then rebanked. The test was then continued for a period of about a week to experiment with different methods of draft control and of firing the coal. From the results obtained it has been concluded that the following method of banking should be followed in putting a boiler on a long bank, the steam pressure being maintained at about 80 per cent of full operating pressure.

1. Burn the fire as low as can be done with reasonable efficiency. It was considered that this point was reached when the flue gases fell to 5 or 6 per cent CO_2 or when the fire bed was just thick enough to cover the tuyeres. In doing this, the stoker is kept turning at the slowest speed and the air kept up to normal or less as the fire gets thin, so that when the fire is properly reduced, the coal hopper should be empty and as little as possible of green coal in the firebox. With the fuel bed in this condition the damper should be closed to maintain the draft over the fire between zero and 0.02 in. of water until the next period of supplying coal.

It was found that such a fire, with heat stored in the furnace walls, was sufficient to keep the boiler to line pressure for about twelve hours. No trouble was experienced in allowing the stoker to stand for ten or twelve hours after the fire had been burned down in this manner. Blocked rams are caused usually by allowing a stoker to stand idle when it has a heavy charge of green fuel.

2. When the boiler shows a tendency to fall below the line pressure, the automatic cutoff valve should be closed by hand.

3. After the automatic valve has been closed, the stoker should be run one revolution every two hours, supplying 180 lb. of coal to the furnace. If coal shows a tendency to form coke, the slash bar should be used to break it up just before the stoker is turned over. Also, it is beneficial at times to apply ½ to ¾ in. of air pressure under the fire for a few minutes at the time

*Excerpt from report of the Station Operating Committee of the National District Heating Association.

of running the stoker and using the slash bar to liven up the fire. Between periods of replenishing the fire the damper should be kept closed to hold the draft over the fire as low as practicable, meaning between zero and 0.05 in. in this case.

It was found that short periods of forced draft applied as directly as possible under the active part of the fuel bed was better than induced draft applied continuously.

4. Do not dump or clean away the ashes from the lower part of the stoker.

In general, keep the fuel bed light, keep it burning close up to the front wall, use the slash bar and draft control to avoid formation of unburned coke and avoid all unnecessary air being driven through the boiler setting that will lower the temperature.

When taking the boiler out of bank, great care should be used to see that the fire hugs the front wall and that the speed of the stoker is regulated by the speed at which the coal ignites when it gets into the furnace.

It is a question of stoker and air control for the first five minutes. Care in starting and the proper precautions during this period to see that the fire is where it belongs, means that after five minutes the stoker can be put on high speed and with the necessary amount of air the boiler can be brought to almost any rating desired inside of twenty minutes.

Fire-Controlling System for Hand-Fired Furnaces

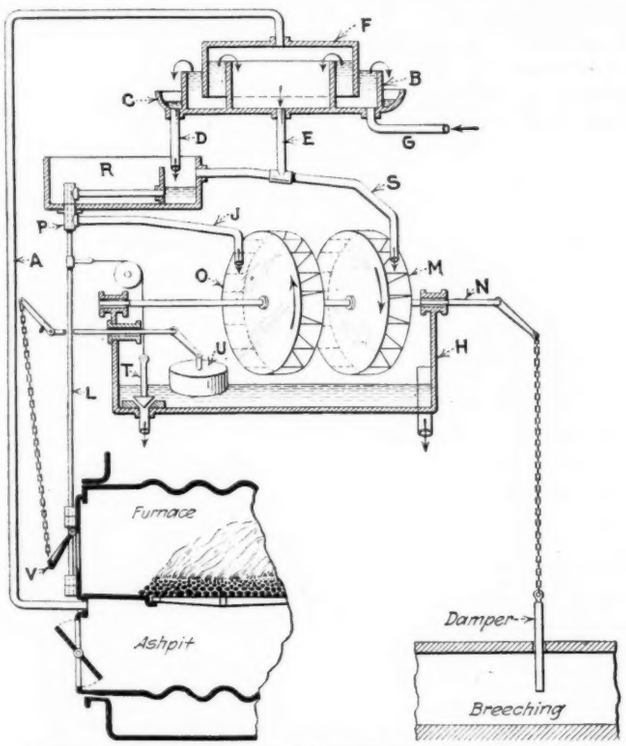
Since firing a furnace by hand necessitates opening the door at short intervals, and since raking, breaking up and cleaning change at each period of firing the compositions of the waste gases and result in considerable difference of temperature, the economical operation of a boiler under these conditions depends to a large extent on the intelligence and good will of the fireman.

With a view to eliminating as far as possible the human factor in the regulation of the draft and the admission of secondary air immediately after firing, a regulator has been developed by H. Liese, of Hamburg, Germany.

The apparatus has been developed on the principle that the chimney produces practically a constant draft and the resistance through the boiler is rather constant, so that the only variable items are the resistance of the fuel bed and the pressure on the ashpit, which are in reverse proportion to each other. A thick fuel bed produces a high resistance and therefore permits only a slight suction in the ashpit, in which case the damper on the breeching must be fully opened. If the fuel bed is thin, the conditions are reversed and the damper must be closed.

The working of the apparatus is shown by the sketch. From the ashpit the tube *A* goes to the regulating apparatus *B* consisting of a ring-like channel *C* with two overflows. The outward overflow indicated by the arrows is about $\frac{1}{16}$ in. lower than the inward overflow. Over the channel there is fixed a cover *F* to which the tube *A* is connected. If the force of draft is greater than $\frac{1}{16}$ in., the water, which is constantly supplied to the channel by the tube *G*, flows through the tubes *E* and *S* to the vessel *H* and moves the damper by means of the wheel *M* and the shaft *N*. From the illustration it may be seen that in this case, when the resistance in the layer of fuel is small and therefore the draft in the ashpit is increased, the damper will be practically closed. In the reverse case—high layer of fuel and therefore high resistance of grate—the water runs by the outward overflow and the tubes *D* and *J* to the wheel *O*, and the damper is opened.

In order to shut the damper as soon as the door of the furnace is opened, the door is coupled to a turning valve *P* by means of the rod *L*, which at the same time shuts the connection between the tubes *D* and *J* and forces the water coming from *C* to gather in an extra compartment of the basin *R* and to flow to the tube *S*; thus the shaft *N* is turned again in the direction of shutting the damper. As soon as the door is shut by hand, the valve *P* is re-opened. In the meantime the compartment belonging to it is filled with additional



REGULATOR CONTROLS DAMPER IN BREECHING AND ADMISSION OF SECONDARY AIR IMMEDIATELY AFTER FIRING

Some parts shown in perspective for the sake of clearness

water by means of a float, not shown in the illustration, so that all the water contained in *R* flows to the wheel *O* and opens the damper quickly.

To provide additional air above the fire immediately after firing, there is fitted to the basin *H* an outlet valve *T* and a float *U*. When the firing door is opened, the outlet valve *T* is drawn open, so that the basin is drained and the float *U* sinks down, causing the air shutter *V* in the furnace door to open. This shutter is shut again by and by, after closing the door by the increasing water and the rising float *U*. The time of closing may be regulated to the contents of gas of the coal by changing the adjustment. Being operated by the two water-levels, the apparatus is very sensitive to the least differences of pressure in the ashpit. It must, however, be adjusted for a certain kind of fuel and the amount of coal burned per square-foot of grate surface according to analysis of the flue gases. Also for boilers with forced draft the difference of the water levels may be changed according to the amount of coal burned.

Reconnecting Direct-Current Machines—Changes in Voltage—I

Practical Hints To Keep in Mind When Making Changes in a Machine for a New Voltage—Problem Worked out To Show the Different Methods that May Be Used To Make the Change

By A. C. ROE*

QUITE often it is required to change the operating voltage of an existing direct-current machine, the commonest cases being from 220 to 110, 500 to 250 or 110 to 220 volts. There are certain factors that govern the extent to which the voltage may be changed in a given machine. This and following articles will deal with these features and apply them to practical examples. In all cases it is required to make the desired change at the least expense consistent with a good job.

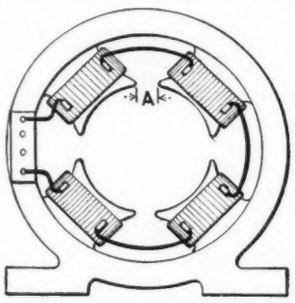


FIG. 1—FIELD COILS CONNECTED IN SERIES

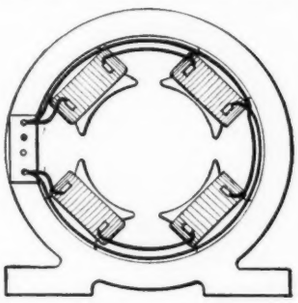


FIG. 2—FIELD COILS CONNECTED SERIES PARALLEL

In all the following cases it is assumed that the speed is to remain the same and in some cases the horsepower on kilowatt rating is to remain the same, also that no change is to be made in the amount of iron in the magnetic circuit. Then the only parts in which a change can be made are the armature and field windings, commutator and brushes.

As the machines under observation have been running satisfactorily before the contemplated change, the size of wire, ampere-turns in the winding and magnetic density in the core can be used as a base and the required change reduced to a proportion $\frac{E_1}{E_2} = \frac{T_2}{T_1}$, or $T_2 = \frac{E_2 T_1}{E_1}$, where E_1 equals the original voltage, E_2 the new voltage, T_1 the turns per coil for the original voltage and T_2 the turns per coil required for the new voltage. This is equivalent to saying that the voltage varies directly as the number of turns connected in series in the winding. If the number of turns in series is doubled, the winding will be good for double the voltage; if the number of turns in series is reduced by one-half, the winding will be good for one-half the original voltage. Likewise the size of wire in circular mils per coil can be found by the proportion, $\frac{E_1}{E_2} = \frac{A_2}{A_1}$, or $A_2 = \frac{E_1 A_1}{E_2}$, where E_1 and E_2 have the same meaning as in the foregoing, and A_1 equals the cross-sectional area in circular mils of the original wire and A_2 the area of the new wire. This is an inverse proportion and is equivalent to saying that where the winding is changed for double the original voltage the cross-sectional area of the copper in the coils may be halved, and where the voltage is reduced by one-half the cross-section area of the copper should be doubled.

The first formula can also be used to determine the turns per field coil and the second formula for the size

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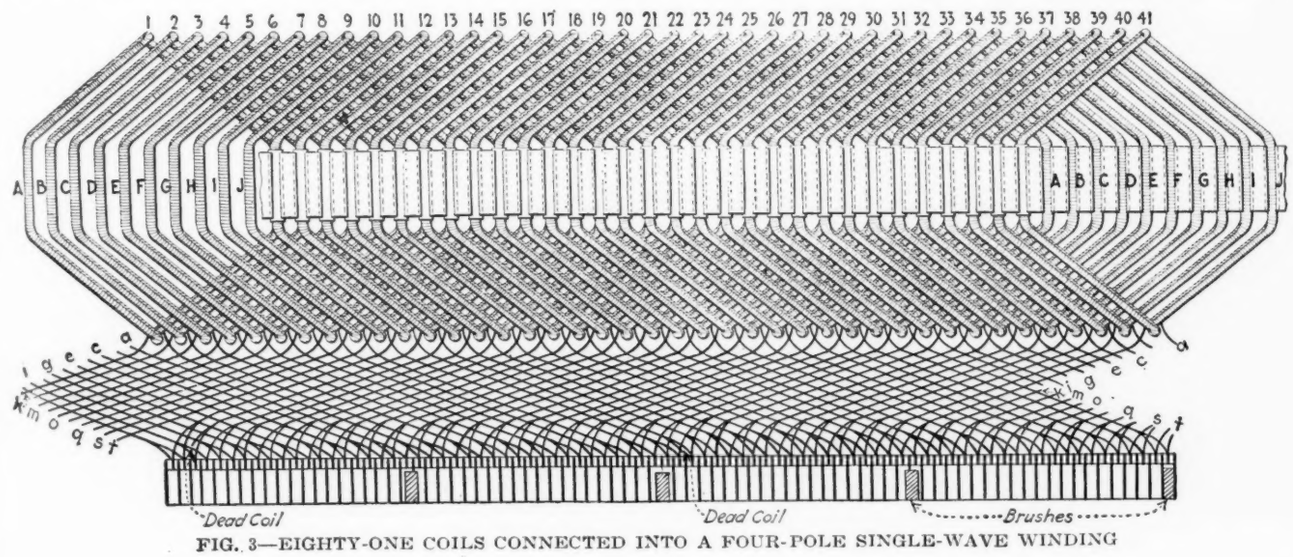


FIG. 3—EIGHTY-ONE COILS CONNECTED INTO A FOUR-POLE SINGLE-WAVE WINDING

of wire in the new field coils. In any case when changing the voltage the magnetic density in the iron and the circular mils per ampere, in both the armature and field conductors, should be kept constant.

For the magnetic density to remain the same in all parts of the magnetic circuit, the ampere-turns on both the armature and field poles must be kept at the same value. To accomplish this, the turns per coil, both armature and field, must be changed in the same proportion and direction as the voltage is changed, and the cross-sectional area in circular mils of the wire used in the armature and field coils must also be changed in the same proportion as the voltage, but in the opposite direction. In other words, when the voltage is to be increased the turns in the armature and field will have to be increased in the same proportion and the area of the copper decreased. Or if the voltage is to be decreased, the turns in the armature and field are decreased and the copper area increased. This does not, however, mean that there must be a physical change in the number of turns in the coils or in the size of the wire in the winding. For example, if 20 coils are connected in series in one path in the winding and are good for 220 volts and 50 amperes, if the winding can be rearranged in two paths each containing 10 coils in series, then each path will be good for 110 volts and 50 amperes, or a total of 110 volts and 100 amperes. Changing the connections of the winding from 20 coils in series to two groups each of 10 coils in series and these connected in parallel, is the equivalent of rewinding the coils for one-half the number of original turns with wire having double the original cross-sectional area.

Changing the Field Coils

On small machines where the field coils have to be rewound for the new voltage, it is difficult in some cases to count the turns in the coils, as the size of wire

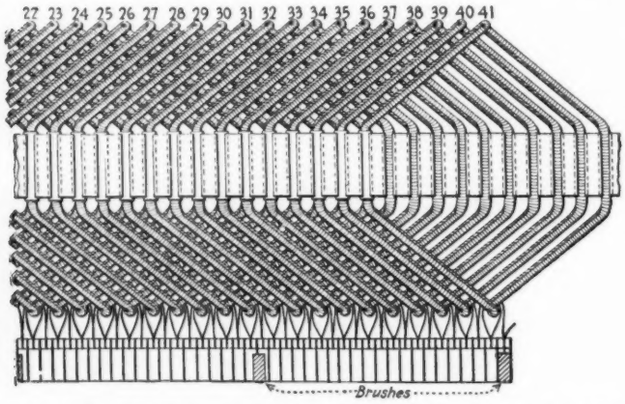
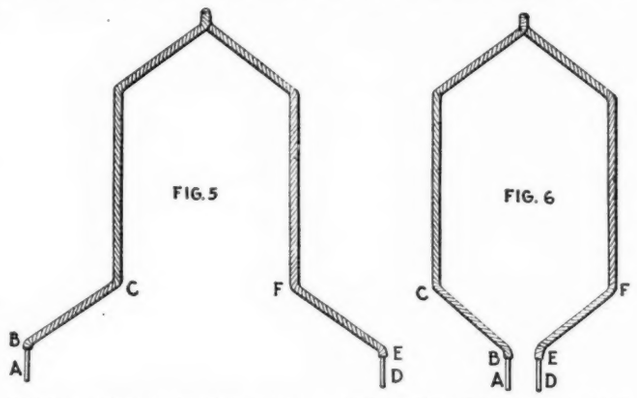


FIG. 4—PART OF THE WINDING FIG. 3 CONNECTED FOUR-POLE SINGLE-LAP

is small and the turns run into thousands. In these cases it is customary to weigh the old coils, calculate the new size of wire, and wind the new coils with the same weight of the new size copper. But whenever practicable the turns per coil should be counted and the new coils wound with the proper number of turns calculated from the count made on the old coils. Attention is called to this because quite often a mistake is made in the weight of the old coil. For example, suppose the old coil had been impregnated with insulating compound and when weighed the old insulation had not been removed. Then if the new coil was built to this weight, it would have considerable more turns than required; the smaller the wire the greater would be the difference in turns.

When the voltage is decreased on either a motor or generator, and the horsepower or kilowatt rating is to remain the same, the ampere rating increases in the same proportion that the voltage is decreased, therefore a greater brush cross-sectional area is required. There are limits to the amount the brush width can be in-



FIGS. 5 AND 6—SHOW COIL LEADS BENT FOR WAVE AND LAP CONNECTION RESPECTIVELY

creased, and the maximum width should not exceed 10 per cent of the width of the neutral region for 125-volt, 7½ per cent for 250-volt and 5 per cent for 550-volt machines. This distance, such as *A*, Fig. 1, can be measured by laying a piece of string on the armature surface from one pole tip to the adjacent one, then measuring the length of the string. If this length is 5 in., then the maximum brush width is $5 \times 0.1 = 0.5$ in. for a 125-volt machine. If this maximum brush width does not give the required brush section, and if the length of the commutator will not permit the use of more brushes then the only solution is to change the grade, if operating conditions permit, to one that will allow using a higher current density. If this current density does not permit the output of the machine, its capacity will be governed by the amount of current the brushes will carry, and the rating of the machine will have to be reduced to a value that will give a safe current density at the required voltage.

Commutator Limits Change in Voltage

When the voltage is increased, it is the commutator again that limits the change, as the voltage between bars must be kept to a safe value; this value is higher for interpole machines than for non-interpole machines. The thickness of mica between bars varies on different machines from 0.02 to 0.04 in., and the total thickness of mica seldom exceeds 15 per cent of the commutator's circumference. The voltage between bars for non-interpole machines varies from 1 to 7.5 for 125 volts, 2½ to 15 for 250 volts and 5 to 20 volts between bars for 500 to 600 volts. On interpole machines the volts per bar may run as high as 35 for 600-volt machines, but the voltage between bars should be kept as low as possible, as this results in a large number of bars, which improves commutation and decreases the danger of flashing over. In any case the maximum voltage per bar should never exceed 35 to 40 on interpole machines. A safe average value is 15 to 25 volts.

The foregoing statements are general and apply to motors and generators that are either shunt, series or

compound wound, with and without interpole. In connection with machines having series and interpole coils, in which the voltage is to be reduced one-half or one-quarter and it is contemplated using the series-parallel connection on the shunt-field coils, a more satisfactory job will result if the series and interpole coils are rewound.

As an example of reconnection, consider a four-pole shunt-wound 220-volt motor, having four groups of brushes on the commutator with flush mica. It is desired to change this motor to operate on 110 volts at the same speed. Inspection shows that the armature has 41 slots and the commutator 81 bars and the winding is wave wound with 41 coils of 4 turns each of two No 11 double-cotton-covered wire per coil. This gives 82 single coils of four turns each, which, with 81 coils connected to 81 segments, leaves one dead coil in the winding. The coils spread 10 slots; that is, if one side of the coil is in slot No. 1 the other is in slot No. 11, the lead pitch on the commutator is 1 and 41, as indicated in Fig. 3. For example, an outside lead of coil 11 connects to segment 1 and an inside lead connects to segment 41, these being the leads of one coil in the group of two. In this problem the voltage is to be reduced one-half, therefore the total turns in series in the field and armature coils must be decreased one-half and the cross-section of the copper doubled, or the equivalent of this obtained.

By dividing the field coils, which in the original connection were 4 in series, into two circuits, each circuit having two coils in series, the field coils can be made good for 110 volts. On 220 volts there were four coils in series of $220 \div 4 = 55$ volts across each coil. By connecting two coils in series per circuit across 110 volts the voltage per coil is $110 \div 2 = 55$, which gives the same results as rewinding each field coil with half the original number of turns and wire twice the size. Fig. 1 shows the field connections for 220 volts and Fig. 2 the connections for 110 volts. If the machine is very old and the coils are in poor condition, it may pay to rewind them with the required turns and size of wire.

Next consider the armature, which is wave-wound or two-circuit, Fig. 3, with four groups of brushes on the commutator. The armature could be reconnected into a lap winding, with four paths, which fulfills the conditions. Reducing the turns in a series by one-half gives the equivalent of doubling the cross-section of the copper. Fig. 4 shows part of the winding grouped in single-lap winding. By following through the circuits in Fig. 3 it will be found that there are 40 coils in series in each of the two armature circuits, which is good for 220 volts. In Fig. 4 there are 20 coils in series in each of the four armature circuits, therefore each circuit is good for only one-half of 220 volts, or 110. In the 220-volt winding each of the two circuits carried at full load about 18 amperes, or a total of 36 for the two. In the 110-volt connection each circuit will still carry about 18 amperes, but as there are four circuits, the full-load current is 72 amperes, or double that for 220 volts. This is one of the simplest ways of solving the problem if other considerations do not prevent. Another point in favor of changing from a wave to a lap winding is that the machine is equipped with four brushes and generally, where a wave-wound machine has as many brush-holders as poles, the brush cross-section is greater than actually required. Therefore in this machine the commutator could be undercut and a brush used having a higher current capacity. In this way the current density in the brushes could be kept within safe limits without changing the brush rigging.

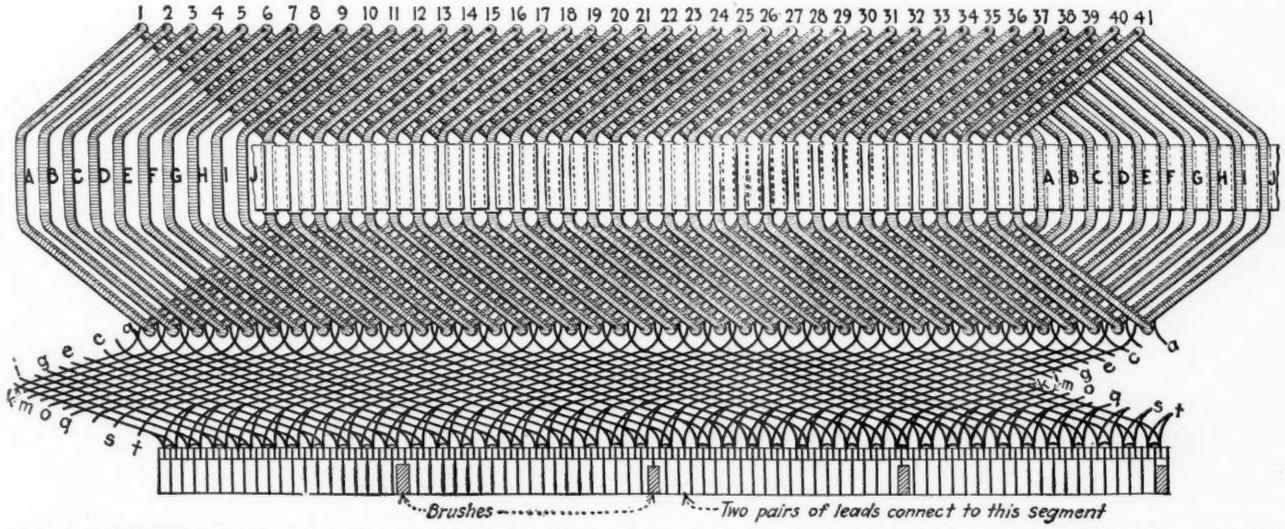


FIG. 7—WINDING FIG. 3 CONNECTED WAVE TWO COILS IN PARALLEL. IF THE CONNECTION FIG. 3 IS GOOD FOR 220 VOLTS, FIG. 7 IS GOOD FOR ONLY 110 VOLTS

Before deciding to reconnect the armature from a wave to a lap winding certain conditions require checking. In a wave winding the leads bend away from the center of the coil and if the brushes are on the center line of the pole, both the top and bottom leads of each coil will have the same throw and approximately the same length as in Fig. 3. If it is required to reconnect to lap, the top and bottom leads must be bent in to the center of the coil as in Fig. 4. The top leads are not so difficult to deal with, but the bottom leads are usually under the ends of the coils and there is not much space between the winding and the commutator. If the machine has been in service for a considerable period, the insulation is likely to be brittle, and with the bending required short-circuits between leads are liable to occur. Therefore, when a change in an armature winding from wave to lap, or vice versa, is contemplated, it may be advisable to remove all the coils from

the armature, and the condition of the insulation would be the factor that determined whether to reinsulate or make up all new coils. With strap-copper coils, two bends will have to be straightened and rebent in each lead. This may result in broken straps or weaken the copper at this point to such an extent that broken leads are liable to occur when the machine is put back in service.

Figs. 5 and 6 explain the bends that require changing when a coil is reconnected from a wave to lap winding. In Fig. 5 is shown a coil for a wave winding; the parts marked *A* and *D* fit into the commutator. Then, if the sections *AC* and *DF* are each bent in toward the center of the coil as in a lap winding, Fig. 6, a double bend will have to be made at points *B*, *C*, *E* and *F* before the leads will be in a position to go into the commutator.

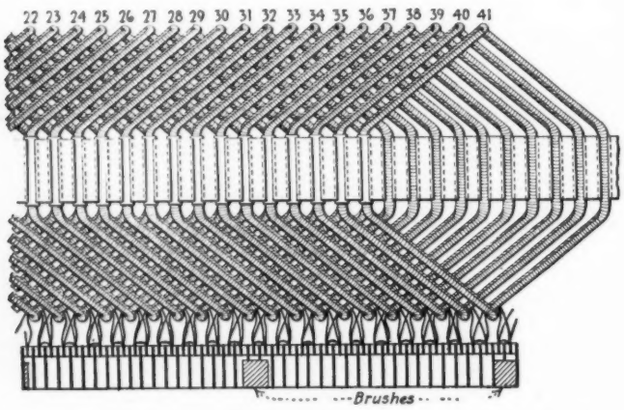


FIG. 8—PART OF THE WINDING, FIG. 3, CONNECTED FOUR-POLE DOUBLE-LAP

If this bending is done without first removing the old insulation, the internal condition of the leads may be weakened and may cause shorts between straps when two or more coils are taped together. With strap copper coils it is best to remove all the old insulation, anneal the copper at the sections marked *B*, *C*, *E* and *F*, then straighten the leads and rebend to the proper shape.

Another way of making the change from 220 to 110 volts would be to make all new coils, with half the turns per coil and twice the cross-section of copper, or in this case two turns of two No. 11 double-cotton-covered wires in parallel, and connect the new winding as was the original. The necks in each commutator bar would have to be cut deeper, as there would be four wires per bar instead of two. In this case it will mean winding the coils with two pairs of wires, and since two coils are taped into one, each pair of coils will have four leads.

Another method of changing the armature would be to change the winding to a double-series (four circuits) connection. This can be done by lifting all the top leads out of the commutator necks and killing one coil and bar, by making a half-idle coil, or by leaving the coil dead and using two adjacent segments as one. There should be a total of 80 active coils and the lead pitch Y should equal $\frac{80 + 2}{2} = \frac{82}{2} = 41$; that is, if the bottom lead of a given coil connects to segment 1, the top lead will connect to segment 42. The pitch of the leads could be $\frac{78}{2} = 39$, or 1 and 40; that is, if the bottom lead of a given coil connects to segment 1, the top lead will connect to segment 40. Either pitch would work, but in most cases it is best to use the original pitch; that is, if the original winding was short-pitched, then connect the new winding short pitch. In the original winding the coil leads were pitched 1 and 41; in the new winding they should be pitched 1 and 40 or one segment less.

If a winding is connected long pitch (progressive) and is changed to short pitch (retrogressive), it will cause a motor to reverse or a generator to fail to generate unless the field or armature leads are interchanged. Where an armature winding is connected single wave with a long pitch on the commutator and changed to a double wave, the leads would have to span one more segment. If this could not be done conveniently on account of the leads being too short, then it might be advisable to change the connections to a short pitch, which would mean shifting the top lead back three segments.

With the double-series connection the commutator segments cannot be grouped in pairs by jumpers, since the coils connecting to each pair of segments do not lie in the same state, and unless a good brush fit is maintained at all times, commutator trouble may be experienced. What amounts to considering the winding make up of 41 coils wound with two wires in parallel and connected single wave is shown in Fig. 7. In this winding 80 of the segments are connected in pairs, leaving one single segment which is treated as a pair. The leads of the dead coil are brought out so that there are 41 double coils. This gives the equivalent of 41 coils and 41 segments. Two pairs of leads are connected to the single segment as indicated in the figure.

If the original brushes have sufficient current carrying capacity, they may be used on the winding, Fig. 7, without any consideration of how many segments they span. If it were not possible to put the coils in parallel by connecting each pair of segments together, the brushes would at all times have to span at least two segments. Where the winding has single coils, jumpers cannot be placed on the commutator to connect each pair of coils in parallel, which means that wide brushes must be used. Since the coils are in different slots the voltages generated in them are not the same value for any given instance and although this difference may be small for most positions of the armature, it nevertheless is sufficient to set up circulating currents in the coils that will cause serious heating. This feature will be given further consideration in another article.

As a matter of passing interest the winding, Fig. 3, may be connected double-lap, Fig. 8, and be good for 55 volts. With this connection the current will be increased four times, which will in all probability require larger brushes. The field coils will have to be connected four in parallel for 55-volt operation.

Heat Values and Weights Involved in Combustion

One Pound of	Burning to	Weight Of Oxygen, Lb. Required	Weight of Air Required, Lb.	Weight of Combustion Products, Lb.	Heat of Combustion, B.t.u.
Carbon (C)	Carbon dioxide (CO_2)	$2\frac{2}{3}$ (2.67)	11.52	12.52	14,600
Carbon (C)	Carbon monoxide (CO)	$1\frac{1}{3}$ (1.33)	5.76	6.76	4,450
Carbon monoxide (CO)	Carbon dioxide (CO_2)	4/7 (0.571)	2.47	3.47	4,350
Hydrogen (H_2)	Water (H_2O)	8	34.56	35.56	62,100
Sulphur (S)	Sulphur dioxide (SO_2)	1	4.32	5.32	4,000

Reminiscences of a Veteran Mechanical Engineer—VII

An Account of the First Meeting with Theodore Vail, at Which He Is Mistaken for a Member of the Tim Sullivan Social Club

BY W. H. ODELL

The next installment of these articles will be about the Otis Elevator Works at Yonkers and will tell how the "science of steam" proved a greater lure to the author than a job with the elevator people.

ABOUT 1890 there was much complaint about manhole plates being sent skyward by gas explosions in the manholes of the electric cables under the streets of New York City. At that time I was engineer and sales office manager for the B. W. Payne & Sons Engine and Boiler Works, of Elmira, N. Y., with an office at 45 Dey St., New York City, on the site of the present Terminal Buildings.

One afternoon two gentlemen entered the office and made inquiry about a 20-hp. vertical engine. I gave them the list price of $500. From this list price I usually gave a discount to consumers of 15 per cent for cash at 30 days, and an additional 10 per cent to jobbers, but to these gentlemen it was straight list price and for the following reasons:

IN THOSE DAYS ONE PAID PETTY PERQUISITES

I had recently received an order from the Park Department for three sets of engines and boilers to turn the three bridges over the Harlem River that were under the park commissioner's management, and I knew the prevailing custom was that when a merchant or manufacturer received an order for goods from a city department it would be only a short time before some committee would be around to show how beneficial it would be to his business to take a package of tickets for the Tim Sullivan Social Club Ball, or some similar arrangement, and I took these two gentlemen to be one of these committees and wanted to be prepared to "bleed."

After completing the sale and when told to send my proposition around to the Telephone Building and they would send me the formal order, I awoke to the fact that I had misjudged these gentlemen, but it was not until some time later on that I learned that it was Theodore Vail and his chief engineer, whose name I regret is to memory lost.

While looking at the engine, one of which we had on the salesroom floor, Mr. Vail told me their plan was to erect the plant in the basement of the Marlborough Hotel, Broadway and Thirty-sixth Street, take steam from the hotel boilers, and with a large Baker blower, draft the gas and air out of the conduits, etc., and thus keep them ventilated, and asked my opinion of the scheme. I said, "I think you have the cart before the horse," and went on to explain that if a vacuum was produced in the conduits it would add to the trouble, but if they would reverse the operation and keep an air pressure in the conduits a little in excess of the gas pressure on the mains it would be an improvement. They immediately saw the point and the plant was installed on this principle, and was so successful they subsequently gave me orders for several other plants in various parts of the city.

The second day that this plant had been in operation Mr. Vail sent a hurried call for me to come to the

THEODORE VAIL

office, introduced me to a plug-hatted, yellow-gloved person from the gas company, and said the storekeepers, etc., all along that section of Broadway at which "our" plant was established were complaining of the gas in their basements due to the operation of our plant, etc., and Mr. Vail asked what could be done to give relief. I was much younger then than I am now, and replied: "When you asked the gas company to stop the leaks in their service pipes, what reply did they make? Did they not tell you that if you did not want the gas to leak into your conduits, to make them airtight, then you would have no trouble? And I would now advise the gentleman to have his service pipes repaired; that will avoid all trouble and his company will save some gas."

Mr. Vail replied: "I know you are a golden-rule man by preference, but don't you think you are a trifle

harsh? Could you not lower your air pressure until the gas company can repair their pipes?" He was told that if he would so order, the pressure would immediately be reduced. This was done and the following night there were many fires built along Broadway to thaw out the pavements and several hundred men were kept busy all night.

I think this event will show Mr. Vail, as I found him in all my dealings with him, a warm-hearted, broad-minded, true blue American business man, who would not strike an opponent when he was down.

What a Little Draft Did

There were several laughable incidents connected with the installation of these ventilating plants, one of which it may be permissible to relate, as these articles are not written entirely for educational purposes, but rather in a half-holiday style to show what some of us old fellows were up against in the earlier days.

The plant in the Hotel Marlborough was started late one afternoon and was to be cared for by the hotel engineers. I got to the hotel early the next morning before the night clerk, a fine young fellow with a rich brogue, went off duty. As soon as he saw me he yelled: "Say, you there; that damned thing of yours down in the basement near scared the life out of me last night," and then told as follows: About 2 a.m., after all the rounders had quit and everything was quiet, he heard a slight noise out in the hall and on investigating saw an old dust pan that some of the cleaners had left there, "dancing a jig" on the tiled floor. He said the sight was uncanny, but he was too good a "Mick" to be frightened, and thinking it might be a mouse or something of that sort, he called two porters and stationed them, each with a broom, so they could swat whatever it was that ran out. He turned the pan over with a stick, and when nothing appeared, he said that for about a second his hair stood on end and a paleness spread over the faces of his companions but he realized that that thing of mine down in the basement had something to do with it, but how was it? It was explained to him that the blower which took the air out of the basement soon exhausted the air in the entire building, after the doors had stopped swinging on that bitter cold night, but that somewhere in the upper portion of the building a window or door to the roof might have been left open and the current of cold air coming down the stairs and sweeping across the hall was the cause of these strange antics. This explanation relieved the tension and we had many a hearty laugh over the matter later on.

Putting Something Over on the Gang Boss

Shortly after I had been engaged to take charge of the B. W. Payne & Sons New York business, I met an old-time shopmate that I had not seen for years, who had worked in my zone at the Novelty Iron Works. He told me that at the close of the Novelty Iron Works he had established a small steam-fitting shop near the Payne office, and as I frequently had to employ steamfitters for small jobs, I suggested that he do this work; that I did not care for an estimate in advance, but he could do the work on honor and present his bill with the assurance that a check in payment would be mailed the same day the bill was received. This method worked well until it came to connecting up a duplicate of the Hotel Marlborough engine in the new telephone building in Thirty-eighth Street, just off Broadway. There was nothing to do at this plant except connect steam and exhaust to openings near at hand. The steamfitter had taken the measurements, got all his material ready and in company with his son, a lad about twenty years of age, was about completing the job, when Mr. Vail sent for me to come to his office and told me that as my men were not union men I would have to discharge them immediately or the building would be struck at the close of that day. I immediately went to the building and stopped my men, then turned to the gang boss on the main steamfitting job, who with about a dozen of his fitters and helpers were like a lot of cowards "booing" my men, and asked him what he would finish the job for. He told me to go see his boss. This I did, and was given a note back to the gang boss, requesting him to give me an estimate. I do not remember the exact figure, but I think it was a trifle over $50. I protested that there was but about an hour's time needed to finish the job. The reply was, "You don't expect me to connect on that scab work, do you?" When told he could take it all down and re-erect it if necessary, the reply was, "We will not use any of that pipe or fittings, but you will have to get new material from the boss, etc."

Was I angry? Well, if I was I did not show it, but said I would have to confer with my principals at Elmira before I could give answer; but told my men to pack up their tools, etc., and when my carman came he would get them. This order was given with a wink, and I then hastened back to Mr. Vail's office and asked him to give me an order to his watchman at the building to admit me after working hours to get the tools, etc. This he agreed to and was about to telephone the order when I asked him not to do that but rather give me the written order. When asked why the written order, reply was made that my carman was out of town and I did not know just when I could get him, etc., but I could assure him I would take nothing but what belonged to us and I hoped he would not ask any questions that might embarrass me to answer. The order was given me, and when the men came the next morning the job was finished and I heard no more about it, except as Mr. Vail occasionally guyed me about being a confidence man, but that did not cause any loss of sleep.

Is the Compound Ammonia Compressor Worth While?

By H. J. Macintire*

For some time the subject of stage ammonia compression has been discussed, and there appears to be still some doubt in the minds of engineers as to the real advantage of stage compression, if any, and just what should be the details of its operation. In the following, an attempt is made to state clearly each method of compound compression for ammonia, and to bring out all the facts.

Stage compression for ammonia is different from that for air compression because the ammonia is a vapor and during a part of the cycle is a liquid, and because the temperature range is frequently 100 deg. F. or more below the temperature of the atmosphere. Also, unlike air compression, the pressure range varies

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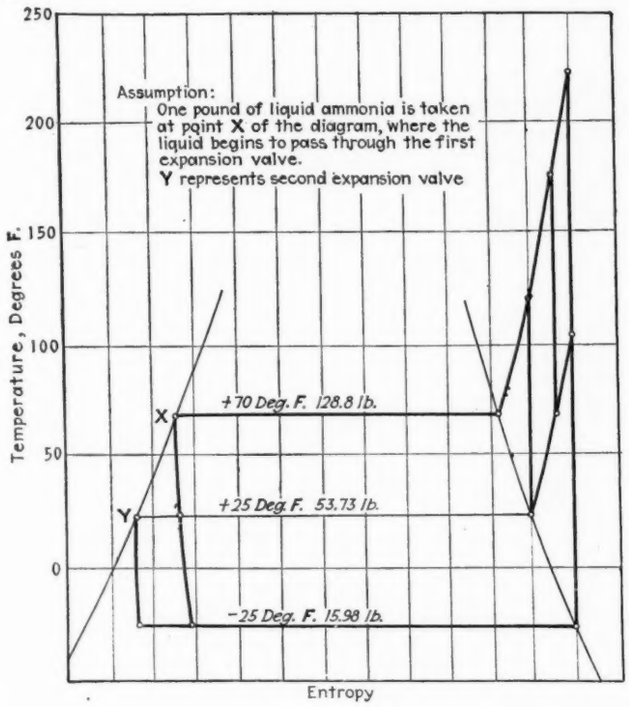
decidedly with the season. In the winter the ratio of discharge to suction pressure may be 6 and in the summer time it may be 12, whereas the discharge pressure, as well as the intermediate pressure for air in the usual air compressor, may remain constant.

With ammonia, also, there is an evolution of gas dur-



Problem	Case A Cool to +25 deg. F. With Liquid NH_3	Case B Cool to 70 deg. F. With Water and to +25 deg. F. With NH_3	Case C Cool to 70 deg. With Water	Case D Simple Compression	Case E No Liquid Intercooling Gas Cooled to 70 deg. F. With Water
Weight of liquid evaporated in cooling l.p. disch. gas, lb.	0.0725	0.04275	.....	.....	.....
Weight liquid evaporated in first exp. valve, lb.	0.0916	0.0916	0.0916	0.178	0.0916
Weight of liquid passing to second expansion, lb.	0.8359	0.8657	0.9084	.....	.....
Weight ammonia as liquid available for refrigeration, lb.	0.7588	0.7860	0.822	0.822	0.822
Refrigerating effect, B.t.u.	445.50	461.0	484.2	482.7	482.7
Work done-l.p. cyl. ft., lb.	44,450	46,020	48,300	.....	53,150
Work done-h. p. cyl. ft.-lb.	39,800	39,800	44,450	.....	44,450
Total work of compression, ft.-lb.	84,250	85,820	92,750	101,400	97,600
Probable vol. eff. h. p. cyl.	0.9233	0.9233	0.9165	0.8110	0.9165
Probable eff. l. p. cyl.	0.9008	0.9008	0.9008	.....	0.9008
Total work—allowing for vol. eff. ft.-lb.	92,450	94,250	102,100	125,000	107,500
Coefficient of performance	3.75	3.81	3.690	3.00	3.49
Hp. per ton of refrigeration	1.257	1.238	1.277	1.568	1.352

COMPARATIVE EFFICIENCIES OF SIMPLE AND COMPOUND COMPRESSION

ing the pressure drop of the liquid in its passage through the expansion valve. This gas is formed by the vaporization of some of the liquid ammonia and may amount to 6 to 15 per cent of the liquid passing through the valve, depending on the initial and final temperatures during this reduction of pressure.

In stage ammonia compression it has been the practice to use two expansion valves and to permit the gas vaporized during the flow through the first expansion valve to pass into the high-pressure cylinder. This is done for two reasons: First, the gas has no refrigerating effect of any value, and permitting it to pass into the low-pressure cylinder simply increases the volume of gas that must be handled. As is known, the volume of ammonia assumes large proportions as the pressure is decreased, and in the following problem it amounts to 9.16 per cent of the volume (9.16 per cent of 16.66 cu.ft.) of each pound of ammonia condensed in the condenser. In addition to this increased volume required in the low-pressure cylinder, if an intermediate separator or receiver is not installed, there is more horsepower required in the low-pressure cylinder because of the increased volume. The horsepower varies directly as the volume of gas in the cylinder at the end of the suction stroke and in this case would be 9.16 per cent greater. The work done in the high-pressure cylinder would be nearly the same in every conceivable case where the same amount of ammonia is handled, and the pressure and the quality of the suction gas to the high-pressure cylinder is the same.

Quality of High-Pressure Suction Gas

Concerning the quality of the high-pressure suction gas various ideas have been developed. The air compressor (dealing as it does with temperatures at or above the atmosphere) attempts to return the gas in the intermediate cooler to the temperature of the atmospheric air. This can be done easily by the use of water-cooling coils. If in stage compression of ammonia the saturation temperature of ammonia at the intermediate pressure is +25 deg. F., it is out of the question to use anything but ammonia to cool down to this temperature, and even +25 deg. is much higher in temperature than the refrigerating coils, which may be, as in the problem, at —25 deg. F.

So intercooling back to the isothermal is out of the question with ammonia stage compression. The very best that can be done in the intercooler is to cool down to the temperature of saturation at the intercooler pressure. This may be done in several ways: (A) Cooling entirely by means of liquid ammonia by permitting the gas discharged from the low-pressure cylinder to pass into a sort of accumulator, where the superheated gas and liquid ammonia will mix. (B) Cooling the superheated gas by water to (say) 70 deg. F. and allowing this gas, superheated 35 deg., to pass into a second cooler where liquid ammonia at +25 deg. is held. The superheated gas will be cooled and some liquid will be evaporated in each of the cases. There is also a case (C) in which the second process (B) is omitted and the gas, superheated 35 deg., is permitted to pass on to the high-pressure cylinder.

Eliminating the Liquid Cooler

Lately, George Horne, of the Merchants Refrigerating Co., has advocated the elimination of the liquid cooler entirely and the use of only one expansion valve, as in case E. The only difference between this method and simple compression is the cooling of the discharged gas from 107 to 70 deg. F. in the problem and the consequent decrease in the maximum temperature of the compressed ammonia and the separation of the compression into cylinders, whereby the volumetric efficiency becomes greater and the superheating effect of the cylinder walls is decreased. Finally, there is the case of simple compression, indicated as case D.

In the table an attempt is made to bring all these cases together. Calculations are made on the basis of one pound of liquid ammonia entering the first expansion valve. From what proceeds, it is evident that the

amount of useful refrigeration at —25 deg. F. (the temperature of the refrigerating coils) depends on the amount of liquid entering the coils, and if the ammonia is used for other purposes such as the cooling of the gas in the intercooler, the decimal part of this unit weight available for useful refrigeration will be reduced. The amount of useful refrigeration, then, depends on the details of the design of the two-stage compressor.

In addition to the refrigeration effect, the work done in the compressor is important. This is usually expressed as horsepower per ton of refrigeration, but it may be expressed also as the coefficient of performance, which is the refrigeration effect divided by the work done in the compressor. The coefficient of performance should be large for efficient operation, and the horsepower per ton of refrigeration should be as small as practical. Both these values are shown in the table on the preceding page.

It would seem that there is slight choice between cases A, B and C. The simpler case C would be, therefore, the one offering probably the best cycle, for although slightly greater power is applied, the plant is simpler and the first cost is lower. The high-pressure cylinder can be slightly smaller than in cases A or B.

A German Engineer's Impressions of the American Oil-Engine Industry*

By Franz Schultz†

American enterprise, factory design and methods employed in manufacturing internal-combustion engines do not differ materially from the German. Hot-bulb or semi-Diesel engines in rated capacities from 200 to 300 hp. with four cylinders are very popular and differ but little from European designs. Few gas engines are being built and these are mostly in large-sized units for operation in steel mills.

The construction of Diesel engines under license from European patents was carried on for years, but its application was confined chiefly to moderate-sized units. Of late the demand for efficiency by the American Merchant Marine has resulted in adopting these engines to replace steam aboard several vessels. The American Navy has also placed many orders for submarine engines, etc., and has proved to be a steady customer. Industrial plants, both large and small, are rapidly installing Diesel engines. The oil companies are employing a large number of horizontal and vertical Diesel engines at their pumping plants.

Although the builders of large Diesel engines have closely adhered to European designs, due to numerous setbacks when adaptation to American practice was attempted, they have made great strides in the development of small oil engines rated between 40 and 60 hp. All makers of this type of engines have adopted a fairly similar design, non-reversible, fitted with inclosed crankcases, forced-feed lubrication, geared governors and push-rod-operated values for the four-stroke-cycle units. New companies are introducing new designs, although these are not always succesful. There is a decided tendency, however, to simplify construction in order to minimize attendance and to meet price competition.

The more experienced makers rigidly adhere to the air compressor, whereas some of the newer concerns are attempting to eliminate it, with more or less success. Solid fuel-injection types follow either the Leissner or the Price ideas. Efficiency, fuel consumption, life and general performance are in some cases better than in air-injection types. The comparatively young American oil-engine industry has accomplished noteworthy results. The workmanship by several companies represents a high standard.

Manufacturing methods scarcely differ from those employed in Germany. Molding machines are in use in all foundries. Complicated castings weighing up to 7½ tons are molded in a remarkably short time. The larger castings are cleaned by sand blasts. After assembling, the cast parts are finished and smoothed over by means of pneumatic chisels. Builders of the larger Diesel engines lay much stress on finish and final appearance. As is the case in Germany, the multi-spindle boring machine is rapidly being replaced by radial boring machines. There is likewise a tendency to dispense with the milling machine and do more work with grinding machines. The small turret lathe of the Bullard type is very popular. Long-stroke planing mills for machining foundation plates are frequently employed. Special lathes and other machine tools are designed by the builders at a cost that sometimes amounts to more than a hundred thousand dollars for a single machine. These special machines permit mass production with assured accuracy and uniformity of parts. For instance, the Nordberg Manufacturing Co. machines the large A frames completely with but a single setting. The Worthington company machines three cylinders simultaneously by means of a special three-spindle boring machine.

Americans Excel in Transporting and Handling Parts

Although American manufacturers employ methods that do not differ materially from the German, they do show a distinct superiority in transporting and handling parts through the shops. The American manufacturer devotes a great deal of thought to the layout of his plant, carefully grouping his machines to facilitate the routing of parts. Individual motor drives greatly increase the flexibility of the machines and permit the necessary speed variation.

Even in shops devoted to the manufacture of light parts the routing is regarded as being of major importance. The parts must travel progressively without retracing ground which has already been covered. The parts are piled in portable boxes which are transported by wheelbarrow or storage-battery-driven trucks to the next operation. The electric trucks run at high speed along unobstructed alleys between the machines. Cranes and hoists are not as popular as formerly.

Another favorable point is the enthusiasm and interest that the American workmen take in efficient production. All Americans are interested in new and practical methods and can adapt themselves to new conditions much more readily than the Germans. The workman likes his work and is ambitious. A review and comparison of the efficiency and intensity with which the American workman goes about his tasks, gives evidence that the outlook for the industrial future of Germany is ominous. It can be brightened only by awakening the technical interest of the men and their recognition as a factor in all production.

*Abstracted from *Zeitschrift Des Vereines Deutscher Ingenieure.*
†Director, Fabrikmotoren Deutz.

EDITORIALS

F. R. LOW, EDITOR

Measuring the Air Supply to Power Stations

IT HAS been frequently remarked that if we got our coal for nothing and had to buy the air with which we burn it, the air would be considered as the fuel and be the object of our solicitude.

Since combustion is a union of combustible substances with the oxygen of the air, we may be able to get as important information from measuring the quantity of air as of fuel consumed. If an insufficient quantity of air is supplied, the fuel is incompletely burned; if too much, heat is diverted from useful purposes to heat the surplus air to the uptake temperature.

If a true sample of the average flue gas can be had, analysis will show whether the combustion has been complete and how much excess air is being used. Apparatus for such analyses in the form of portable Orsat apparatus and of recording CO_2 and CO meters has been reduced to the acme of simplicity and convenience.

David Brownlie, an English engineer specializing in boiler testing, suggests in a recent contribution to *The Engineer* (London) that "what is really required is to inclose the whole boiler plant and admit the air under just as good control and measurement as the fuel and water."

Apparatus is now available for measuring, with a fair degree of precision, large quantities of gas or air flowing in closed passages. It would be ideal if we could have simultaneous records of the weight of fuel bed, the air consumed and the water evaporated. We can see difficulties in making a station "absolutely air-tight" with fuel going into it and ashes going out and laborers constantly passing both ways.

However, the conception is a good one to aim at.

Loss Due to Moisture in Coal

BECAUSE water is so effective in extinguishing fires, laymen, and sometimes engineers as well, are prone to think that moisture in coal greatly reduces the amount of heat that can be delivered to the boiler. A little figuring will show that the heat required to evaporate the moisture content and deliver it as superheated steam at the flue temperature is in reality a very small fraction of the heat in the coal. Suppose the flue temperature is five hundred degrees F. The water in the coal at room temperature (say seventy degrees) is thrown away as superheated steam at atmospheric pressure and five hundred degrees total temperature. This takes 1,247 B.t.u. per pound of water, so each one per cent of water takes about 12.5 B.t.u. per pound of coal or about one-tenth per cent of the heat in the coal. Even ten per cent of moisture would waste only one per cent of heat in the coal. It follows that, if coal is purchased on a B.t.u. basis, the direct loss due to any reasonable moisture content is hardly appreciable. If on the other hand, coal is bought by the pound, the percentage of water makes an important difference. Suppose we take a pound of the given coal and add to it one per cent of water. It thereby becomes 1.01 pounds of coal, and the total cost will be 1.01 times the price of the original pound. So when coal is bought by the ton, without regard to B.t.u. content, each additional one per cent of moisture wastes one per cent of the money spent for coal, including freight.

The big moisture loss comes not from the moisture originally in the coal, but from that produced by the hydrogen content. Each one per cent of uncombined hydrogen in one pound of coal produces upon being burned 0.09 pound of water, which require 112 B.t.u., or about eight-tenths per cent of the heat in 14,000-B.t.u. coal. So five per cent of hydrogen would waste about four per cent of the heat. The conclusion is that if coal is bought on a B.t.u. basis, a large increase in the hydrogen content greatly increases the flue loss due to moisture. If coal is bought by the ton an increase in the content of free hydrogen gives far more in the form of heat than it wastes in additional evaporation and superheating.

Increasing Condenser Effectiveness

CONDENSING equipment has passed through a notable era of improvement along with prime movers, since the twenty-six-inch vacuum of engine practice has given way to the twenty-nine-inch of modern large turbine installations.

At the present time it is possible to obtain a vacuum that is reasonably close to the theoretical limit. It is practicable to approach as near as three-tenths of an inch or less to the absolute pressure represented by the discharge cooling-water temperature. Development of condensing equipment, however, in spite of the satisfactory performance, is by no means at a standstill.

In view of the 950 B.t.u. per pound of steam lost in the cooling water, representing roughly 9,500 B.t.u. per kilowatt-hour generated, the condensing problem has been attacked on the basis of eliminating the condenser and utilizing the greater part of this heat. Exhaust steam, compressed adiabatically to boiler pressure, would finally be delivered as steam. Therefore, a cycle of compression with cooling, by using closed or open heaters for a second system, would be necessary in order to deliver hot water to the boiler element and generate steam for another prime mover. The heat reclaimed from two units would be sufficient for a third of equal capacity, with modern steam conditions, operating condensing, allowing seventy-five per cent heater efficiency. Turbo compressors and coolers or heaters might then displace the condensing equipment. Such plans do not appear attractive commercially at present, and in all probability the rivers and lakes will continue for some time to absorb heat that should be used to replace that of the domestic furnace.

On account of the absolute pressure inside a surface,

condenser being dependent on the temperature of the available cooling water, we find that 50 degrees discharge water would practically limit the absolute exhaust pressure to 0.5 inch; 70 degrees to 1 inch; 85 degrees to 1.5 inch and 100 degrees to 2 inch absolute. While turbines man be constructed to utilize an absolute exhaust pressure of one-half inch, the summer season will probably require an absolute pressure of two inches, representing a loss in steam consumption per kilowatt hour of eight to ten per cent. Since this disadvantage, however, would extend over only a small part of the year, and in view of the fact that economy is being greatly increased by improved utilization of the heat cycle, making less of saving in B.t.u.'s possible by condenser improvement, means of overcoming this disadvantage are not likely to receive much attention at present.

Economy of material, power and maintenance has been proceeding steadily and appears to have much in prospect. Condenser tubes under ideal conditions may transfer from three to five times the amount of heat per square foot per degree as attained in practice. In some instances removing tubes has greatly improved efficiency. Eliminating the dead areas of condensing surface not only brings more steam per minute in contact, but also tends to diffuse the air film on the tube surface, if present. The latter is a great enemy to heat transfer.

A few thousandths of an inch of scale in the water surfaces may reduce the heat transfer many times. Internal tube cleaning has made rapid strides, both as to available tools and also in providing more rapid water circulation, either permanently or temporarily, for the purpose of flushing out sediment.

Internal and external tube films represent the greatest obstacles to better heat transfer coefficients. It is not practicable to do much toward improving conditions of the available cooling water. Cleaning or prevention of deposits on tube surfaces must therefore represent the most effective line of attack. Air infiltration into the steam can be controlled to a great extent, but not entirely prevented. Conditions in starting up, leakage of condenser-tube glands and exposure of condensate to the air represent sources of air access that cannot be altogether avoided. From the fact that in recent years it has practically been found necessary to eliminate oxygen and other impurities from the steam, it seems probable that some attention toward eliminating air from the boiler-feed water in a somewhat similar manner would be worth while.

Lost Research

WHEN it comes to holding every inch of ground gained, the engineers have something to learn from the workers in pure science. It is part of the code of every scientist—whether he be chemist, physicist or astronomer—that no bricks must ever be lost or stolen from the perpetually growing edifice of scientific knowledge. Research has practically been reduced to the formula: First, study and compare all previous work on the given subject; second, start experimental work; third, publish results obtained, tying them in with previous investigations. The scientist never thinks of starting experimental work until he has dug up and digested the published work of all previous investigators in the same field, and published work usually means all worth-while work. This preliminary investigation is greatly simplified, because the previous investigators have likewise taken pains to make their findings easily available to future generations. The chemists have been particularly successful in weaving new developments into the fabric of their science.

The engineer, partly owing to wrong habits, but more largely to conditions beyond his control, has not done so well in this respect. A technical question arises, which some engineer solves at considerable cost of time and money. Ten years later another engineer meets the same problem. Perhaps he has heard of the work of his predecessor. If not, he is likely to plunge at once into expensive experimental work without even troubling to visit a good technical library. But even if he goes there and searches diligently for days, he may come away none the wiser. The results of the earlier experiments may not have been published at all or may have been buried in some obscure periodical whose index files are not available at the particular library. In some large metropolitan library, on the other hand, the very bulk of the possible sources of information may make a thorough search practically impossible.

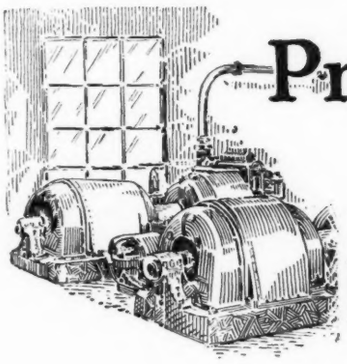
General indexes are available, but they do not cover the field thoroughly. To improve this situation would be no easy task. To co-ordinate knowledge as closely as in the chemical field may be a practical impossibility, because engineering articles generally deal with groups of problems rather than with single problems. The thorough indexing of a single plant description might easily require a hundred different headings. Obviously, the tremendous clerical and printing expense of covering the whole field in such detail would be prohibitive. No real solution of the difficulty is in sight, but much improvement might be brought about by active cooperation of skilled technical librarians with the professional engineering societies in a thorough study of the whole problem of the conservation of engineering knowledge. Engineers will rise up to bless the man who will show them how to locate *all* the published information on any desired engineering subject.

Needed—A Business Man

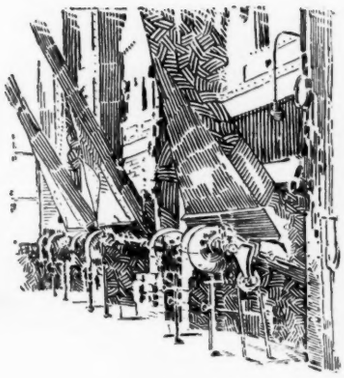
JUST when engineers throughout the country are keenly resenting the summary dismissal of Arthur P. Davis as Director of the United States Reclamation Service, with the curt explanation by Secretary Work that a business man and not an engineer was needed, there comes to light a bit of record that leads one to infer that even an M.D. has his limitations when it comes to administering the business duties of a cabinet position.

Secretary Work, by virtue of his office, is one of the three members of the Federal Power Commission. The suit which the State of New York has instituted in the United States Supreme Court against the Commission has occupied the attention of that body for some time and has been given wide publicity both in the technical and daily press, yet when reference was made to the suit during the recent conference between the Commission and the representatives of the State, Doctor Work unguardedly inquired: "The Supreme Court of the State or the United States?"

That Roman Elder who advised: "Cobbler, stick to your Last," might well have lived in the Twentieth Century.



Practical Ideas *from* Practical Men

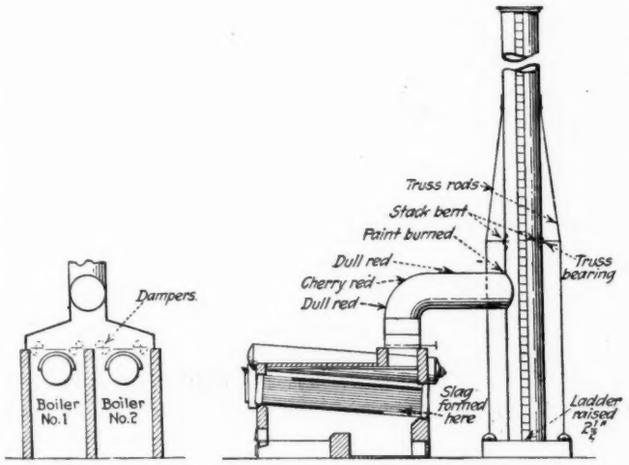


Slagged Tubes Cause Secondary Combustion in Breeching

A few months ago, in response to a call from the engineer, I investigated a boiler plant in Pennsylvania that was behaving in a rather mysterious manner. The breeching between the boiler and the stack at the point where it joined the breeching was heated to such an extent that the paint cracked off and the metal at times became dull red, and yet it was impossible to get full rating from the boilers.

The plant consisted of two 2,500-sq.ft. boilers set in battery, hand-fired and operated with natural draft. According to the engineer they had given satisfactory service for many years, and he was plainly puzzled in defining a reason for the trouble.

Immediately we took draft readings in the furnaces of both boilers, first noting that the dampers were wide open and the fires were of about an even thickness. No. 1 boiler had a draft of 0.4 in. of water; No. 2



ARRANGEMENT OF BOILERS, BREECHING AND STACK

had a draft of 0.1 in. This clearly indicated that the gas passage in No. 2 boiler was obstructed by some foreign substance, as both boilers were baffled alike. We found, on removing several plugs from the hollow staybolts, that No. 2 boiler was slagged badly between the tubes at the opening of the lower baffle. A similar inspection of No. 1 showed that it was clean.

A dull-red smoky flame was passing all the way through boiler No. 2, while in the clean boiler, which was under heavier operation, there was no flame above the bottom baffle. There was no sign of overheating at the point where gases passed from boiler No. 2 into the breeching. Farther along, where the gases from the two boilers met, the breeching became red, and from there on into the stack it was cherry red. All the paint had been burned off at the base of the stack where the breeching entered. It was this condition that puzzled the engineer, for the breeching directly on top of the boilers at no time showed that it was overheated. The paint was not even blistered. The semi-supporting steel stack had three truss rods and a ladder extending from base to top. The ladder was originally embedded in the concrete base, as shown in the illustration.

Actual measurement showed that the ladder had pulled away 2½ in. from the concrete base. The three truss rods, which were normally somewhat loose, were taut and the strain on them was so great that they had buckled the stack. This, of course, was caused by the expansion of the stack, which left it in an exceedingly dangerous condition.

While the engineer said that their coal was supposed to be a good grade of bituminous, an analysis showed it to be a poor grade containing a large percentage of iron oxide, which was the cause of the slag formation on the tubes.

If a draft gage had been connected to the furnace of these boilers, it would have been a simple matter for the attendant to observe that the boiler was choking with slag. This might have remedied the condition before it affected the production of the plant and injured the breeching and stack. A clean boiler, proper baffling and correct combustion never cause hot breechings.

R. E. BURKE, Investigating Engineer,
St. Louis, Mo. Heine Boiler Co.

Use of Rubber Plug Reduces Cost of Cleaning Condenser Tubes

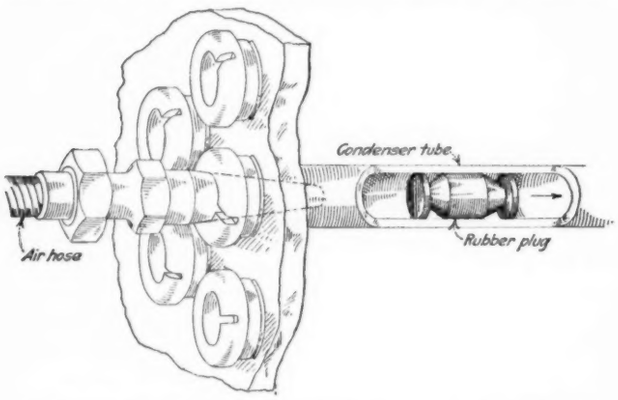
The method in use at our plant of cleaning condenser tubes, although not new, may be of interest to readers who are not familiar with this practice.

An air hose fitted with a suitable nozzle is led to each end of the condenser. The plug is forced through a tube in one direction by air pressure and is caught at the other end and returned through another tube.

Our company has been using the condenser plug exclusively for cleaning condensers for the past two years and has found that they do the work as well as wire brushes or other methods of cleaning, and at a considerable saving in time and money. In fact, the condition of our system at the present time is such that condensers on our larger units would have to go for

three or four weeks at a time without being cleaned if the old methods of cleaning were used.

By the use of the plug we are able to clean a condenser with as many as 9,000 tubes between midnight and starting time the next morning, which is usually about five or six o'clock. This work is done with four or five men as against fifteen to seventeen formerly used, and with this larger number of men using wire brushes from twelve to sixteen hours were required to clean the condenser completely. At an average wage of fifty cents an hour it is seen that approximately one hundred dollars in labor alone is saved at one cleaning of the condenser. This of course does not take into account



PLUG IS FORCED THROUGH TUBES BY AIR PRESSURE

the larger saving in fuel as a result of being able to clean condensers more frequently and thereby maintain a higher vacuum.

In one of our stations a condenser crew of four men cleans each week nine condensers varying in size from those on 6,000-kw. units to those on 20,000-kw. units.

New York City. A. E. CLARKE.

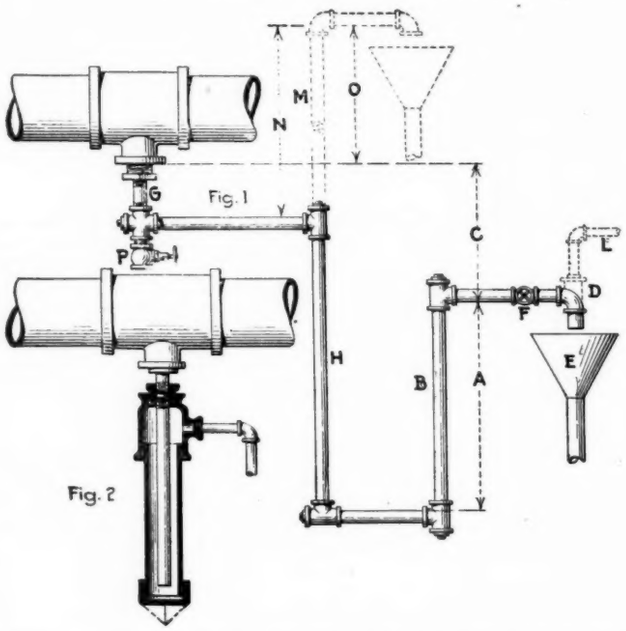
Advantages of the Water-Seal Trap for Draining Low-Pressure Steam Lines

The water seal possesses so many advantages over other forms of steam trap on a low-pressure system that the comparatively small number in use may be taken as an indication that the average engineer, both designing and operating, is not fully alive to its possibilities. It is probable that nearly every engineer has more or less knowledge of this trap, but let him look over his own plant and see if one or more could not be installed to advantage to replace some worn-out trap or where there is none at present.

A typical water-seal installation is shown in Fig. 1, the two essential features being that the distance *A* shall be sufficient to prevent the steam pressure blowing the water out of the leg *B* and that the distance *C* shall be sufficient to allow the discharge of water with the minimum pressure that will be found in the steam pipe. If the pressure will never fall below the atmosphere, the distance *C* need not be more than a few inches. If an appreciable pressure of steam is maintained at all times, *C* may be negative; that is, the discharge ell *D* may be above the lowest point in the steam line. As one pound per square inch is equivalent to a head of approximately 2.4 ft. of water, the distance *A* must be at least 2.4 times the maximum gage reading that will be obtained; if circumstances will permit, it is a good plan to add a few feet to this calculated length to allow for fluctuations of pressure that have not been anticipated. The funnel *E* allows the engineer to see just what the trap is doing; some vapor will be given off by the hot water and, in case of the seal being broken, a considerable quantity of steam. If this is objectionable, a tee should be substituted for the elbow *D* and a vent pipe *L* led to a convenient location. This will prevent a siphon action in the discharge pipe and will indicate, by the escape of steam, the loss of water in the seal. A valve should always be provided at *F;* in case the seal is broken it is only necessary to close this valve for a few minutes to allow it to form again. Failure of the seal, however, is a sure indication of excessive pressure in the system, at the same time acting as a most reliable relief valve.

As the water seal has no restricted passages or moving valves, it is much less liable to become clogged than the ordinary trap, and it cannot become airbound. Sediment, however, is likely to collect at the lowest point, and one or more plugged tees should be used in place of ells to facilitate the cleaning of the pipes. If the conditions are unusually severe, tees may be used in place of all ells, as shown in Fig. 1.

The engineer is likely to be too hasty in the conclusion that he is unable to obtain sufficient space for the installation or that it will require too much pipe. This will probably be the case for pressures above 25 lb., but for 5 lb., which is usually the maximum on a heating system, or ½ lb., which is generally the limit on an atmospheric exhaust, a practicable method of installation can generally be found. There is no restriction as to the maximum lengths of any of the sections



FIGS. 1 AND 2—APPLICATIONS OF THE WATER SEAL FOR DRAINING LOW-PRESSURE STEAM PIPES

or to the number of ells that may be introduced. A little digging may be resorted to, if required, to get sufficient drop; it is not necessary to have the sections vertical and horizontal, they may be run at any angle so long as air pockets are avoided and the vertical distance *A* between high and low points is maintained. Pipe trenches may be utilized where available and the line carried to some pit or well to obtain the necessary

drop. If the steam pressure is certain to be maintained at a practically constant value, the piping for the water seal may be almost entirely above the steam line as shown at *M*. In this case, however, the water will be blown out if the pressure rises above a value equal to the distance *N*, in feet, divided by 2.4; and no water will be discharged if the pressure falls below the distance *O* divided by 2.4. It is therefore advisable to have as great a difference as possible between the dimensions *N* and *O* and to install a valve at the low point *P* in order to drain the system when there is no pressure; it is advisable when practicable to keep the discharge below the pipe to be drained.

In some cases it may be necessary to drain a line in which the pressure sometimes falls below the atmosphere. This may happen in some heating systems and occasionally with the exhaust steam going into a feed-water heater. In most cases the commercial trap will fail under these conditions; and some types may fail to open at all; if they do they will probably admit water or air into the steam line unless special provision is made to guard against this action. The arrangement shown in Fig. 1 will work satisfactorily provided that the distance *C*, in feet, is equal to or exceeds 1.14 times the vacuum, measured in inches of mercury, and that the water is not drawn out of the seal when changing from pressure to a vacuum. The latter contingency is rather unlikely to occur in any case and may be easily guarded against. If the design is such that the distance *C* is greater than *A*, the water level will stand near the bottom of leg *H* when working at maximum pressure; in changing over to a vacuum, the water will rise in leg *H* and perhaps *G* until its level exceeds that in *B* by the distance *C*. If *B* does not hold enough water to supply the amount necessary for *H* and *G*, air may be drawn through. The remedy is to make *B* of larger pipe or to allow *D* to discharge below the surface of an open tank.

An arrangement that sometimes works well is shown in Fig. 2, in which there is no danger of air being drawn back, as described in the preceding paragraph, and which may be used to obtain sufficient drop where other methods fail. This can be placed to one side of the pipe or in any convenient location, instead of directly below the pipe as shown. The outer section of the pipe may be driven into the ground in the same manner as driving a well by closing the end with a pointed cap as shown by the dotted lines. Sediment may be removed by disconnecting the inner pipe from the steam line and blowing out with high-pressure water or steam, or if it is packed hard the inner pipe and the tee may be removed and the obstruction broken by means of a rod. If considerable space is left below the inner pipe for a sediment pocket, it is probable that cleaning will never be necessary.

Washington, D. C. H. M. PHILLIPS.

Planimeter Used for Averaging Charts from Recording Instruments

There are instruments sold for averaging CO_2 charts, etc., but to those who, like myself, have but little averaging of charts to do, the following information may prove of value.

We receive daily from one of our power plants a CO_2 chart and a flue-gas temperature chart. These accumulate quite rapidly, and I found it quite a task, even with the use of an adding machine, to average them up at all accurately. Having a planimeter in the office, it occurred to me that I could make use of it for this work, and I evolved a simple formula which now enables us to average a chart in about a minute, where before it took several minutes. The formula is derived as follows:

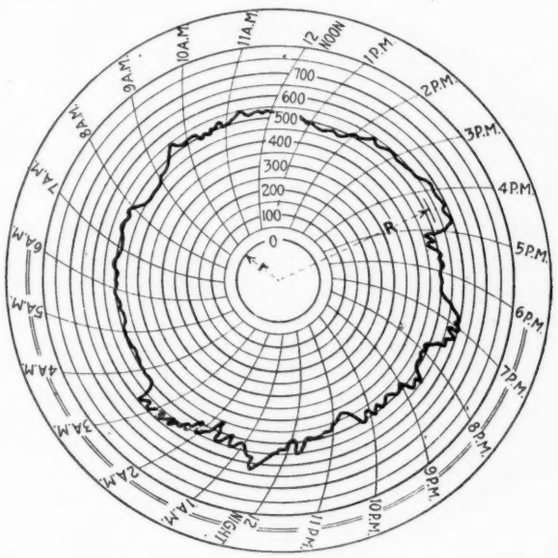
$$\text{Area of circle} = \frac{\pi D^2}{4}$$

$$D = \frac{2}{\sqrt{\pi}}\sqrt{A} \text{ or } 1.13\sqrt{A}$$

Therefore, the average radius *R* of any chart $= 0.565\sqrt{A}$.

The foregoing is the general formula. It can be applied to any particular chart in the following manner:

Measure the distance *r* from the center of the chart in consideration to the zero line. If the zero line is not shown, locate it by scale in the proper place. Now, $(R - r)\ K =$ average reading of chart where *r* is



TYPICAL RECORDER CHART ON WHICH THE AVERAGE TEMPERATURE IS READILY FOUND BY THE USE OF THE PLANIMETER

the distance from the center of the chart to the zero line and the constant *K* is determined from the scale of the chart. It may read 240 deg. F. per in. or 12.5 per cent CO_2 per in., etc.

Substituting our value for *R* from the general formula, we get $(0.565\sqrt{A} - r)\ K =$ recorded reading of chart, where *A* is the inclosed area of the chart record found by running around it with a planimeter.

For example, here is the way we applied it to one of our charts: On the gas temperature chart, the scale is 240 deg. F. per in. and the distance from the center of the chart to the zero line is 0.55 in. Therefore, $K = 240$ and $r = 0.55$ in. The formula, then is

$$(0.565\sqrt{A} - 0.55)\ 240 = \text{average temp. of gas}$$

Simplifying this,

$$\text{average temp.} = 136\sqrt{A} - 132 \text{ deg.}$$

As can readily be seen, having found *A*, to take the square root and multiply by 136 is a simple matter on the slide rule. Then, subtracting 132, we have our average reading. In a similar manner the formula can be applied to any chart. P. B. JAMESON.

Boston, Mass.

Comments from Readers

Comments on the Benson Super-Pressure Plant

My experience and that of my associates would lead us to question some of the assumptions made in the articles on the Benson Super-Pressure Plant in the May 22 and 29 issues.

In the first case it is assumed that steam is generated at the critical conditions without boiling or without bubbles, yet the diagrams *b*, *c* and *d* of Fig. 2 in the first article show an increase of volume due to superheating, which is clearly necessary if the steam is to be throttled to 1,500 lb. without becoming too wet for a turbine.

Theoretically, or in a laboratory test tube, water may change to steam at the critical point without boiling. But if the process is continuous, as in a coil-tube boiler, I do not see how bubbles can fail to form nearest the hot walls. They must move with the flow of liquid, and when they increase in volume owing to superheating, they must burst. We do not know much about the surface tension of liquids at high temperatures and pressures, but it seems reasonable that bubbles will form and burst. This is boiling.

On page 799 the following statement is made: "The throttling involves no heat loss." I would refer to page 49 of Professor Stumpf's book on "The Una-Flow Steam Engine" (Second edition), as follows: "Throttling is a change of state in which the total heat remains constant (except for radiation losses), the effect of which is to diminish the amount of heat and the pressure difference available for utilization between boiler and condenser."

And Stumpf gives an entropy diagram in Fig. 2 which shows the loss of heat energy *available* exactly parallel with what occurs in the Benson throttling as may be seen from the entropy chart (Fig. 3 of the second article). Part of the area under *mn* is loss, is it not?

So it seems to me doubtful if it pays to pump water against 3,200 or 3,300 lb. per sq.in. to use steam at only 1,500 lb. At that point it is so nearly saturated that it must be resuperheated to be palatable to the turbine. Why not generate it and superheat it at 1,500 lb.? At least Mr. Benson will find out for us. An engine of the proper unaflow design might save him the resuperheating process demanded by the turbine. It might even take the steam at 3,200 lb. and 100 deg. superheat direct. It might produce a high efficiency, operating compound or multi-expansion, of course. Would it pay? That is a question for further research to decide.

On page 844 the second article proceeds to suggest reheating between stages, after "laying aside the use of bleeder heating." No doubt this is favorable to a turbine where fluid friction is to be avoided. But it seems to me that consideration of high pressures demands attention to engines as well as turbines, and to regenerative cycles that are much nearer to Carnot efficiencies than any shown in Fig. 5 of the second article. Bleeding and heating cycles would show better and better efficiencies at higher pressures and temperatures. Professor Stumpf had worked this all out in diagrams and had designed engines and boilers when I first met him in January, 1912. I suggest that Mr. Benson use his multiple-feed pump to try out reheating cycles.

You note the precautions used in testing tubing, etc. I should be interested to know how Mr. Benson makes his joints and takes care of expansion at different parts of his plant. I do not see how he can consider it safe to weld parts of his coil end to end. The A.S.M.E. Boiler Code will not allow any autogenous weld subject to tensile strains.

But boilers can be designed and built for up to 4,000 lb. working pressure, using standard tubes and conforming to A.S.M.E. Codes. There is no difficulty with priming at 800 lb. if liberating surfaces are ample and the height from the water surface to the steam take-off is sufficient and suitable baffles and drying surfaces are provided. Watch the air bubbles break on the surface of the tanks in the Aquarium at the Battery in New York, and you will see why. Most high-pressure boilers have been deficient in steam space. Large drums are neither desirable nor necessary. But neither is a so-called flash boiler, similar to Benson's, in which the coils deliver hot steam on light loads and cooler on heavier loads and demand most delicate control of feed pumps to give any control over steam temperature at all.

It seems to me that the editorial, "Thirty-two Hundred Pounds Steam Pressure," in the May 22 issue, raises some vital questions, and the note near the bottom of the last column on the following page indicates that more might be said in this direction. *Power* is to be congratulated on this interesting presentation of the subject of high-pressure steam, and I look for more discussion with interest.

C. C. TRUMP.

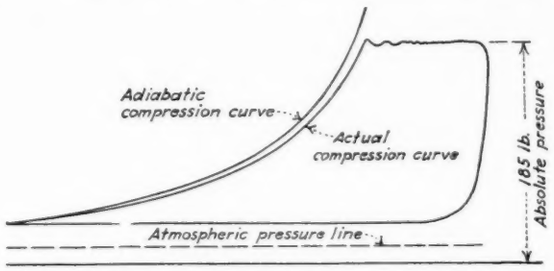
Syracuse, N. Y.

[The quotation from Professor Stumpf is in entire agreement with the articles in stating that throttling involves no loss of total heat, but does involve a loss of available heat. The articles do not question the well-known fact that there is a loss of available heat, due to throttling. Suppose a turbine operates with the throttle steam at 200 lb. gage and 200 deg. superheat, the steam being generated in this condition by the boiler. If the boiler pressure is raised to 300 lb., the superheat changed to 181 deg., and a reducing valve placed between the boiler and the turbine to cut the pressure down to 200 lb., the steam at the turbine throttle will be exactly the same as before; namely, at 200 lb. and 200 deg. superheat. The turbine will therefore have the same water rate. If the boiler efficiency remains the same, and if the difference in feed-pump work between the two cases be neglected, a pound of steam at the turbine throttle will require exactly the same number of pounds of coal in the boiler as before.

Therefore, the method of steam generation has not affected the plant over-all efficiency. It should be carefully noted that this comparison applies only where the throttle pressure and superheat are the same in both cases. The plant efficiency could, of course, be increased by supplying the steam to the engine at 300 lb. rather than at 200. The phrase, "laying aside the use of bleeder heating" was not intended to indicate that bleeder heating could not be advantageously used with high pressures, the exact opposite being the case. The intention was to indicate that space was lacking for going into the subject of bleeder heating. An editorial on page 864 of the May 29 issue recommends a careful study of bleeder possibilities at high pressures.—Editor.]

Relative Temperature and Pressure in Ammonia Compression

In *Power* of July 3, on the "Questions and Answers" page is an inquiry from "C. D." concerning the proper discharge temperature of an ammonia compressor. The editorial reply is based on the quite common assumption that the compression is adiabatic or nearly so. While it may be true that if an indicator diagram be taken from a compressor cylinder that has correct adjustment of valves, and the adiabatic curve be plotted thereon, the latter will be but a small distance above the actual pressure curve, affording a basis for the statement that the compression is nearly adiabatic, I



COMPRESSOR CURVE WITH $N = 1.22$ COMPARED TO THE ADIABATIC

contend that the difference between the actual and the adiabatic compression has a marked effect on discharge temperature.

At ordinary suction pressure and with genuine "dry" compression the discharge temperature would be higher than the inquirer states if the compression were in fact adiabatic. This can be proved by the interesting chart in *Power* of Sept. 26, 1922. If the suction gage pressure be taken as 20 lb., or about 35 lb. absolute, and the compressor discharge at 170 lb. gage, 185 lb. absolute, and if at the beginning of the compression stroke the ammonia be a perfect saturated vapor, then the temperature of the discharged gas will be 223 deg. after true adiabatic compression. If the ammonia has been heated 20 deg. in the warm cylinder at the instant when compression begins, the discharge temperature will be 242 deg., or if heated 40 deg. the discharge temperature will be 274 deg. The saturation temperature at 20 lb. gage is about 5.5 deg., but the cylinder is warm, possibly hot to the touch, and the incoming vapor must necessarily take on some superheat in passing the valves and coming in contact with the hot piston face and cylinder. The temperature when actual compression begins will thus be something above the 5.5 deg. prevailing in the suction pipe. The discharge temperatures here given were computed by formula, but the chart which appeared in *Power*, Sept. 26, 1922, gives substantially the same results if read with sufficient accuracy.

The formula used for finding the discharge temperature, assuming that ammonia behaves in accordance with the gas-compression theory, is written thus:

$$T_c = T_e\left(\frac{P_c}{P_e}\right)^{\frac{n-1}{n}}$$

in which

T_c = Absolute temperature of the gas after compression;

T_e = Absolute temperature of the gas before compression.

P_c = Pressure, absolute, of the compressed gas at discharge;

P_e = Pressure, absolute, of the gas before compression;

n = A constant, depending on the gas and conditions of operation.

If the compression be truly adiabatic, as so often assumed, the accepted value for n is 1.30. But adiabatic compression means that no heat whatever be lost by the gas to any other substance during the compression stroke, and this condition does not obtain in actual work. A small quantity of heat is radiated from the cylinder. Some goes to the entering gas, heating it above the suction temperature of saturation. Nearly all compressors have a water jacket, and the water circulated through it comes out several degrees warmer than it entered, and heat that has caused that rise in temperature being a portion of the heat of compression. Furthermore, nearly always the ammonia comes to the compressor in such condition that it makes frost show nearly to, or at, the suction valves, and it is quite possible that a small quantity of unvaporized ammonia,

DISCHARGE TEMPERATURES OF COMPRESSED AMMONIA GAS
Discharge pressure, 170 lb. gage. Value for n in formula = 1.22

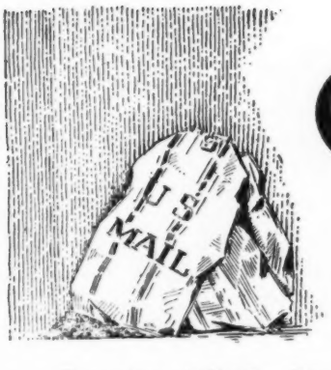
Suction		Superheat when stroke begins			
Gage, Lb.	Temperature	0 Deg.	10 Deg.	20 Deg.	30 Deg.
30	16.6	155	168	181	194
25	11.3	162	175	188	201
22	7.9	166	179	193	206
20	5.5	169	183	196	210
18	3.0	173	186	200	213
16	0.4	176	190	203	217
14	−2.4	180	194	208	222

in a very finely divided state, passes into the cylinder, requiring there a little heat to complete its vaporization. All these factors conspire to alter the value of n.

In the case in hand the value 1.22 is probably nearer to the correct than 1.30. Using 1.22 in the formula given, with suction gage pressures varying from 14 up to 30 lb., the table herewith has been computed, showing discharge temperatures for the saturated condition and also when there is 10, 20 and 30 deg. of initial superheat. It will be seen that some of the temperatures thus found agree with those specified in the inquiry; namely, 180 to 190 deg. F.

If the correspondent were to take an indicator diagram from the compressor and plot thereon the adiabatic curve (easily done by a method given in *Power's* book, "Practical Refrigeration"), the result probably would be about what is shown by the theoretical diagram herewith, which is based on $n = 1.22$ for actual operation and $n = 1.30$ for the adiabatic. The difference on the diagrams may seem small, but the influence on discharge temperature is considerable.

Atlanta, Ga. W. S. HUNTINGTON.



QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Foaming of Boiler from Temporary Use of Better Water

Why should a boiler foam from temporary use of a better quality of feed water? L. R.

By feeding a purer water, scale and sediment left in the boiler from previous use of a poorer quality of water may become loosened or partly dissolved, and suspension of the material, combined with more active ebullition in places where the old scale has become removed, results in foaming, the same as from use of dirty feed water.

Use of Alum-Treated Feed Water

We are using in our boiler, water that has been treated with soda ash and lime and from the same water we make our ice. While the ice is of good quality and our boiler is scaling but very little, we have been informed that an alum treatment of the water would further improve the appearance of the ice. What effect would alum treatment of the water have on the scaling of the boiler? D. J. L.

Alum in boiler-feed water produces a deposit that becomes converted into a hard white scale unless the boiler is frequently blown down and washed out before scale hardening takes place. Where alum is used for aiding the process of filtration of municipal water supplies, the alum deposits from use of the water as a boiler-feed water usually can be taken care of by washing and cleaning the boiler at ordinary intervals, depending on the alum treatment given the raw water, which usually is varied according to the amount of sediment to be removed. The effect of using a proposed proportion of alum should be tried out a day or two before a regular time for opening and washing the boiler and similar trials should be made, gradually increasing the number of days' run with the treated water prior to cleaning, to determine the length of time the boiler could be operated without formation of unremovable scale.

Fraction of Total Steam Supply Chargeable to Pipe Line

When steam is supplied to a drier through a long pipe line, does not the weight of condensate trapped from the line at the drier as compared with the condensate discharged from the trap and drier represent the fraction of the whole supply that is chargeable to the pipe line? J. A. Y.

If the steam is received in dry saturated condition and there is no material drop of pressure in the line, then condensate caught at the trap would be fairly representative of the expenditure of steam chargeable to the pipe line, and the fraction of total supply so chargeable would be the weight of condensate discharged by the trap divided by the sum of the trap discharge and the condensate discharged during the same time from the drier. But if the initial supply from the boiler contains water entrained with the steam, the condensate trapped from the pipe line probably would include a considerable part of such water and the fraction of the whole supply chargeable to the pipe line and trapping would depend on the quality of steam as received by the pipe line and as received by the drier, weight of condensate discharged by the trap, and weight and temperature of condensate discharged by the drier.

Where, in one pound (weight) of dry saturated steam at the pressure of steam received by the pipe line, as given in steam tables,

L = Latent heat, B.t.u.;
h = Heat in the water;
q = Quality of steam received by the pipe line;

and for one pound of dry saturated steam at the pressure discharged by the pipe line to the drier,

L_1 = Latent heat, B.t.u.;
h_1 = Heat in the water, B.t.u.;
q_1 = Quality of steam discharged by the pipe line and received by the drier;
w = Weight of water trapped off from the pipe line per hour;
W = Weight of water discharged from the drier per hour;
t = Temperature of water discharged from the drier;
f = Fraction of total supply chargeable to pipe line and trap.

Then,

B.t.u. used by drier $= (q_1L_1 + h_1 + 32 - t)W$,

If the drier were supplied with steam of the initial quality without intervention of the pipe line or trap, the quantity would be

$$\frac{q_1L_1 + h_1 + 32 - t}{qL + h + 32 - t} W \text{ lb. per hour.}$$

Hence the greater number of pounds required per hour due to employment of the pipe line and trap would be

$$(w + W) - \frac{q_1L_1 + h_1 + 32 - t}{qL + h + 32 - t} W$$

and the fraction of the total supply chargeable to pipe line and trap would be

$$f = (w + W) - \frac{q_1L_1 + h_1 + 32 - t}{qL + h + 32 - t} W \div (w + W),$$

or

$$1 - \frac{(q_1L_1 + h_1 + 32 - t)W}{(qL + h + 32 - t)(w + W)}$$

Setting Steam Valves of Duplex Pump

What is the method of setting the steam valves on a duplex pump? M. C.

The general rule is to place the pistons of both sides at the centers of their strokes and set the steam valves in central position with relation to the ports. As the valves have no lap, their outer edges will be flush with the outer edges of the ports. In this position the valve-rod clearance, or lost motion, must be divided evenly so there may be the same amount of lost motion on either side of the valve or at either end of the lost motion link. The total lost motion may be made about 0.3 of the travel of the rocker pin for contact stroke and can be adjusted later if the pump is not working properly.

To place pistons at the center of their stroke, move them first to contact with one head and then with the other, and mark each position on the rod against the stuffing-box gland. Then make a mark on each piston rod between these marks and move each rod until the middle marks come against the glands. This will place the pistons in central position, and the valve motion arms should stand perpendicular to the rods. If this is not the case for either side, the "spool," or crosshead, must be disconnected and the position corrected.

Next remove the steam-chest covers and place the slide valves central with the ports and adjust the lost motion so as to have the same clearance on either end. To lengthen the stroke on either corner of the pump, increase the lost motion of the valve on the other side and at that end which is in contact.

Derivation and Conversion of Baumé Gravity

What is the derivation of the Baumé scale of gravity of liquids and formulas for converting Baumé readings to specific gravity? H. L. M.

The gravity scale known as the Baumé scale was first proposed and used in 1768 by Antoine Baumé, a French chemist. His directions for setting up his scale state that for the hydrometer scale for liquids heavier than water he used a solution of sodium chloride (common table salt) containing by weight 15 parts of salt and 85 parts of water. He describes the salt as being very pure and dry and states that the experiments were conducted in a cellar in which the temperature was 54.5 F. The point to which the hydrometer sank in the 15 per cent salt solution was marked 15 deg. and the point to which it sank in distilled water at the same temperature was marked 0 deg. The space between these points was divided into 15 equal parts and divisions of the same length were extended beyond the 15 deg. point. For the hydrometer for liquids lighter than water he used a 10 per cent salt solution for fixing the zero, and distilled water for the 10 deg. point. The distance between these points was divided into 10 equal parts and divisions of the same length extended above the 10 deg. point.

Other makers of Baumé hydrometers deviated from the procedure outlined by the originator, and in course of time many different Baumé scales came into use, based on different assumed relations to the specific-gravity scale and different standard temperatures at which the instruments are intended to be read.

The United States Bureau of Standards has determined that for liquids lighter than water, the true relation between the Baumé gravity and specific gravity, where the liquid at 60 deg. F. is referred to water at 60 deg. F., is expressed by the formula:

$$\text{Specific gravity at 60 deg./60 deg. F.} = \frac{140}{130 + \textit{deg. Bé.}}$$

and for liquids heavier than water,

$$\text{Specific gravity at 60 deg./60 deg. F.} = \frac{145}{145 - \textit{deg. Bé.}}$$

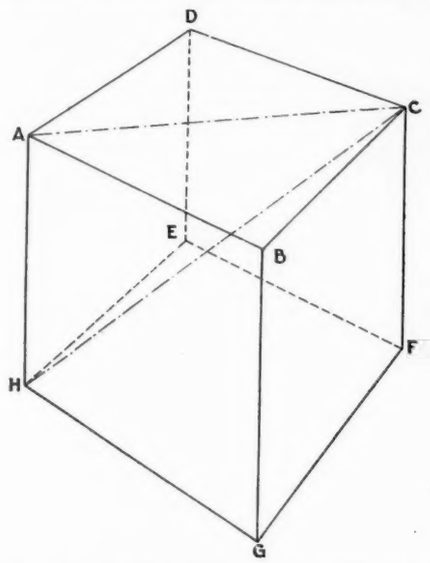
The readings on the Tagliabue hydrometer, which is much used in the oil trade, may be converted to the corresponding figures for specific gravity by the formula

$$\text{Specific gravity 60 deg./60 deg. F.} = \frac{141.5}{131.5 + \textit{deg. Bé.}}$$

Volume of Largest Cube Within Sphere

What is the volume of the largest cube that can be contained within a hollow sphere 18 in. in diameter? H. B. A.

The diagonal of the largest cube that could be contained by the sphere would be equal to the diameter of the sphere. Suppose that in the cube *A B C D E F G H*, shown in the figure, *HC* is a diagonal of the cube and



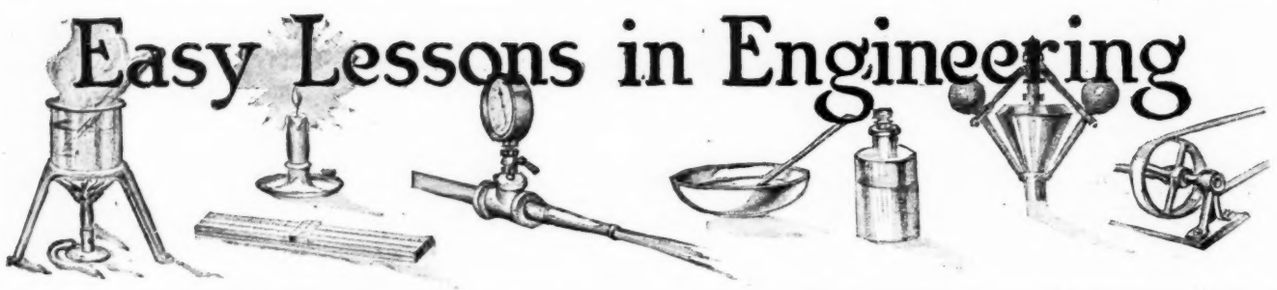
DIAGONAL OF CUBE EQUALS DIAMETER OF SPHERE

AC is the diagonal of a side *ABCD*. Then as *AHC* and *ABC* are right-angle triangles, $\overline{HC}^2 = \overline{AH}^2 + \overline{AC}^2$ and $AC^2 = \overline{AB}^2 + \overline{BC}^2$.

If the dimensions of the cube were $1 \times 1 \times 1$, then $\overline{AC}^2 = (1)^2 + (1)^2 = 2$ and we would have $\overline{HC}^2 = (1)^2 + 2 = 3$ or $HC = \sqrt{3} = 1.7321$, and the length of one edge *AB* or *BC* or *BF* of any cubs is $\frac{1}{1.7321}$ or 0.5773 part of the diagonal of a cube. Hence, where the diameter of the sphere and consequently the length of diagonal of the largest cube containable is 18 in., the length of one edge of the cube would be 18×0.5773, and its volume would be $(18 \times 0.5773)^3 = 1{,}122.1$ cu.in.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Easy Lessons in Engineering



How To Use the Steam Tables—I

There are so many difficult problems involving the use of the steam tables that many who are unaccustomed to this kind of figuring get the impression that the steam tables would be of no use to them unless they went through a long course of training. This is far from being the case.

In order to make this and the following article on the steam tables as practical as possible, a few extracts from the Marks and Davis steam tables will be reproduced for reference. The accompanying table gives extracts from the "Saturated Steam—Pressure Table." The first column is headed "Press., Lb." The figures in this column are the absolute pressures, lb. per sq.in., or 14.7 more than a steam gage would read. For the present it will make the work simpler and be sufficiently accurate for most purposes to call atmospheric pressure 15 pounds.

Suppose we want to see what happens when water at 32 deg. F. is converted into steam at 100 lb. gage pressure. The absolute pressure is 115 lb. Looking on this line in the table, we see, in the second column, that "Temp., Deg. F." or "*t*" is 338.1. This is the boiling point of water at 115 lb. absolute. It is also, as will be explained later, the temperature of "saturated" steam at the same pressure.

Suppose one pound of melted ice at 32 deg. F., the freezing point, is placed in a vertical cylinder beneath a tight frictionless piston loaded by weights to 100 lb. per sq.in. The additional pressure of the atmosphere brings the total pressure to 115 pounds.

Suppose, now, that heat is applied to the bottom of the cylinder so that it passes without loss into the water. The temperature rises approximately one degree F. for each B.t.u. (British thermal unit) supplied. In going from 32 deg. to 338.1 deg. (the boiling point) the rise in temperature will be 338.1 — 32 = 306.1 deg., so that the heat supplied will be approximately 306.1 B.t.u.

To find the exact amount, turn to column 6, which gives the "Heat of the Liquid" (represented by *h* or by *q*, where we read 309.0 B.t.u., instead of 306.1. This "heat of the liquid" is the actual amount of heat required to raise the temperature of one pound of water from 32 deg. to the boiling point at the given pressure. It would be very convenient if it always took exactly one B.t.u. to increase the temperature of one pound of water one degree, but the heat required to do this varies a little with the temperature. So the B.t.u. has been defined as the *average* amount of heat required to raise the temperature of one pound of water one degree over the range from 32 deg. to 212 deg. (the boiling point of water at atmospheric pressure). Where steam tables are not at hand, no serious error is introduced if it is assumed that, for one pound of water, the B.t.u. requirements are exactly equal to the temperature rise as long as the water stays in the liquid state.

No steam will be formed until the boiling temperature of 338.1 deg. F. is reached. At that temperature the pressure of the water vapor becomes equal to the total pressure on the piston with the result that the piston is lifted by the steam evolved from the water.

The lifting of the piston proceeds in exact proportion to the amount of heat added until all the water is evaporated. If a thermometer were placed in the water and another in the steam, both would register 338.1 deg. throughout the evaporation process right up to the point when all the water was evaporated. Steam at the boiling temperature is always called "saturated" steam. If it contains little particles of water or fog, it is "wet saturated steam." If not, it is "dry saturated steam." Wet steam is always saturated, but saturated steam may be either dry or wet. Steam at a temperature above the boiling point is said to be "superheated." To superheat steam it is usually necessary to remove it from contact with water.

We have, at the moment when evaporation is complete, one pound of saturated steam at 115 lb. absolute or 338.1 deg. F. From column 4 we see that the volume of one pound ("Specific Volume") of steam under these conditions is 3.88 cu.ft. Correspondingly, we see from column 5 that the weight of one cubic foot is 0.2577 lb., this figure being the reciprocal of 3.88.

The heat required merely to evaporate the water or to produce one pound of saturated steam from one pound of boiling water is given in column 7 as 879.8 B.t.u. It should be noted that this "latent heat of evaporation" is much larger than the "heat of the liquid." The word latent means hidden and is used

TABLE I—EXTRACTS FROM "SATURATED STEAM-PRESSURE TABLE"

(1) Press., Lb. *p*	(2) Temp., Deg. F. *t*	(3) Press., Atmos. —	(4) Sp. Vol. Cu.Ft. per Lb. *v* or *q*	(5) Density Lb. per Cu.Ft. $1/v$	(6) Heat of the Liquid *h* or *q*	(7) Latent Heat of Evap., *L* or *r*	(8) Total Heat of Steam, *H*	(9) Internal Energy B.t.u. Evap. *I* or ρ	(10) Internal Energy B.t.u. Steam *E*	(11) Entropy Water η or θ	(12) Entropy Evap. L/T or r/T	(13) Entropy Steam *N* or ϕ
1	101.83	0.068	333.0	0.00300	69.8	1,034.6	1,104.4	972.9	1,042.7	0.1327	1.8427	1.9754
14.7	212.00	1.000	26.79	0.03732	180.0	970.4	1,150.4	897.6	1,077.5	0.3118	1.4447	1.7565
15	213.0	1.021	26.27	0.03806	181.0	969.7	1,150.7	896.8	1,077.8	0.3133	1.4416	1.7549
20	228.0	1.361	20.08	0.04980	196.1	960.0	1,156.2	885.8	1,081.9	0.3355	1.3965	1.7320
65	298.0	4.423	6.65	0.1503	267.5	911.0	1,178.5	831.4	1,098.7	0.4344	1.2024	1.6368
115	338.1	7.83	3.88	0.2577	309.0	879.8	1,188.6	797.9	1,106.5	0.4877	1.1030	1.5907
215	388.0	14.63	2.138	0.468	361.4	837.9	1,199.2	754.0	1,114.6	0.5513	0.9885	1.5398

because the latent heat produces no rise in temperature. Roughly, 90 per cent of it is used up in tearing the molecules of water apart to form the steam, the remaining 10 per cent being used up in the external work of lifting the piston.

Column 8 gives "Total Heat of Steam" as 1,188.8. This is nothing but the sum of the "heat of the liquid" and the "heat of evaporation." It is therefore the total amount of heat required to change one pound of water at 32 deg. into one pound of saturated steam at the given pressure.

The actual steam tables, it will be understood, have lines for all pressures from 1 lb. up as high as they are commonly used.

The discussion of the remaining columns 9 to 13, dealing with "Internal Energy" and "Entropy," will be reserved for the next article. Before applying the information given in the first eight columns to practical problems, we will briefly summarize their meaning as follows: (1) Pressure, pounds per sq.in. absolute; (2) temperature at which boiling occurs and also

TABLE II—EXTRACTS FROM "TEMPERATURE" TABLE FOR SATURATED STEAM

(1)	(2) Pressure	(3)	(4)	(5)	(6)	(7)	(8)
Temp. F.	Lb. per Sq.In.	Inches of Hg.	Sp. Vol., Cu.Ft. per Lb.	Density Lb. per Cu.Ft.	Heat of the Liquid	Latent Heat of Evap.	Total Heat of Steam
	p	—	v or s	$1/v$	h or q	L or t	H
32	0.0986	0.1804	3,294.0	0.000304	0.00	1,073.4	1,073.4
79	0.4893	0.996	657.0	0.001523	47.04	1,047.3	1,094.3
101	0.975	1.985	341.0	0.002933	68.97	1,035.1	1,104.0
212	14.70	29.92	26.79	0.03732	180.00	970.4	1,150.4

temperature of saturated steam; (3) absolute pressure in atmospheres; (4) volume of one pound of saturated steam; (5) weight of one cubic foot of saturated steam; (6) heat required to raise one pound of water from 32 deg. F to the boiling point; (7) heat required to evaporate one pound of water already at the boiling point; (8) total heat required to heat up and evaporate one pound of water starting at 32 deg. (this is the sum of columns 6 and 7).

A few examples will illustrate some of the important practical uses of these columns.

Problem: How much heat is required per pound to produce steam in a boiler where the steam pressure is 200 lb. gage (215 lb. abs.) and the feed temperature 170 deg. F, assuming that the steam is dry and saturated as it leaves the boiler?

Solution:

Total heat in dry-saturated steam at 215 lb. abs.	1,199.2 B.t.u.
Heat in water at 170 deg. = 170 — 32	138.0 B.t.u.
Net heat required to evaporate feed water	1,061.2 B.t.u.

In solving this problem, we assumed that the number of B.t.u. in the feed water was equal to its temperature minus 32. As previously explained, this is not absolutely exact, but no important error is involved for any water temperature below 212 deg. The true value of the heat content of 170-deg. water is 137.87 B.t.u., so that the error here is seen to be of no practical importance. The following problems show other uses of the table.

Problem: How much heat is required to produce 4.5 lb. of 97-per cent dry steam at 100 lb. gage pressure (115 lb. absolute) from feed water at 205 deg.? What is the total volume of the steam produced?

Solution: To produce 97-per cent dry steam, *all* the water must first be heated to the boiling point. Then 97 per cent of it is evaporated, the other 3 per cent remaining water in the form of a fine mist. First solve the problem for one pound of water and then multiply the result obtained by 4.5. The computations follow:

Heat in pound of water at boiling point	309.00 B.t.u.
Heat to evaporate 0.97 lb. (.97 x 879.8)	853.4 B.t.u.
Total heat of pound of 97 per cent dry steam	1,162.4 B.t.u.
Heat in pound of water at 205 deg. (205-32)	173.0 B.t.u.
Net heat to produce pound of 97 per cent dry steam	989.4 B.t.u.
	x 4.5
Net heat to produce 4.5 lb. of 97 per cent dry steam	4,452 B.t.u.
Volume of pound of 97 per cent dry steam (0.97 x 3.88)	3.76 cu.ft.
	x 4.5
Volume of 4.5 lb. of 97 per cent dry steam	16.9 cu.ft.

Problem: How many pounds per hour of dry saturated exhaust steam at 5 lb. gage (20 lb. absolute) will be required to deliver 1,200 gal. of water per hour at 180 deg. from a supply at 60 deg. if an open-type heater is used.

Solution: The first step is to find how much hot water could be furnished by one pound of exhaust steam. The steam entering the heater will first be condensed and then the condensate will be cooled to 180 deg. The heat given up per pound of steam will be:

In condensing	960.0 B.t.u.
In cooling from boiling point to 180 deg., (228.0-180)	48.0 B.t.u.
Total	1,008.0 B.t.u.

To heat one pound of water from 60 to 180 requires 180 — 60 = 120 B.t.u., so one pound of steam could heat up 1,008 ÷ 120 = 8.4 lb. of water. The pound of condensate would be delivered along with this, giving 8.4 + 1 = 9.4 lb. of hot water per pound of steam. Taking the usual figure of 8.33 lb. per gal. (strictly correct only for cold water), this gives 9.4 ÷ 8.33 = 1.13 gal. of hot water per pound of steam. Therefore to produce 1,200 gal. per hour would require 1,200 ÷ 1.13 = 1,061 lb. of exhaust steam per hour.

The original table of which Table I is an extract goes up by steps of even pounds to 250 lb. and thereafter by somewhat larger steps. At very low pressures, such as those found in condensers, pressure steps of one pound are too large for practical work. To avoid interpolation, another table is given in which the saturation temperatures are placed in the first column, these temperatures increasing by steps of single degrees up to 400 deg. and thereafter by steps of ten degrees.

Table II is an extract from this table. For convenience in working low-pressure problems an additional column (No. 3) is given for pressures in inches of mercury. The other items are the same as in Table I. The use of Table II is illustrated by the following problem:

Problem: How many pounds of cooling water will be required per pound of exhaust steam by a condenser carrying a 28-in. vacuum if the inlet temperature of the circulating water is 65 deg. F.? Assume that the temperature of the condensate and also of the outlet circulating water is 10 deg. below that of the saturation pressure, and that the exhaust steam is dry saturated.

Solution:

Absolute pressure of exhaust	2 in. of mercury
Nearest steam-table pressure	1.985 in.
Corresponding saturation temp.	101 deg.
Temperature drop of condensate	10 deg.
Outlet temperature of condensate	91 deg.
Heat given up by exhaust steam per pound:	
Latent heat	1,035 B.t.u.
Cooling 10 deg.	10 B.t.u.
Total	1,045 B.t.u.
Outlet temperature of cooling water	91 deg.
Heat absorbed per pound cooling water (91-65)	26 B.t.u.
Cooling water per pound steam, (1,045÷26)	40.1 lb.

Developments in Power Production

The developments now taking place in power production were summarized by O. Junggren, of the General Electric Co., in an address delivered at the recent convention of the Stoker Manufacturers Association. A digest of his remarks follows:

The electrical industry started out by catering to wealth and luxury. In a short period it has changed to the most fundamental industry of the country—that is, the supply of power—and has truly become the servant of the masses. Most of our power comes from coal. The industry is vitally interested in the efficiency with which the heat of this coal or other fuel is turned into electrical energy. The use of steam for converting heat into power has been considered wasteful in comparison with gas engines, but for large powers the probability that the steam cycle will be superseded is far removed. Further, it is well recognized that steam cycle, worked to the limit, has theoretical possibilities closely approaching the efficiency of the gas and oil engine. What this limit is in practice will depend greatly upon the ingenuity with which present materials are handled and new processes developed. The use of combination cycles of steam, mercury vapor and other vapors to effect a considerable degree of economy has been proposed, but such arrangements are still in the experimental stage.

The New Developments Outlined

Steam pressures have been increasing rapidly. There has also been a noticeable increase in steam temperatures. These, with the steadily increasing size of main units, have resulted in a large gain in efficiency. The rapid growth of the power industry has created a demand for a special type of turbine, sometimes called the "best-load machine." In large centers it is sometimes feasible to have "best-load stations," leaving the stations in the outlying districts to furnish the variable load. Such "best-load" units and stations warrant the maximum provisions for economy.

The intensive study now being made of heat balance is leading to a considerable increase in economy. The advantages of such studies are, of course, greatest where the plant operates at a high load factor.

The average pressure decided upon for the new stations is around 350 lb. gage, and the temperature about 700 deg. to 725. Heating the feed water by extracting steam from the main unit is being generally adopted, with a corresponding reduction in B.t.u. consumption per kilowatt-hour. One station of this class is arranging to heat the incoming air to the boilers by steam extracted from the main unit.

There are three new stations under construction for steam pressures of 550 lb. and temperatures up to a maximum of 750 deg. In addition they will reheat the steam after it has passed through a certain portion of the turbine. The American Gas & Electric Co. is planning two stations with a total capacity of 140,000 kw. at present, and the Commonwealth Edison Co., in Chicago, one station with a present capacity of 160,000 kw. From this you will note that the development, although somewhat radical in its nature, is carried out upon a large scale. In Europe considerably higher pressures and temperatures (1,500 lb. and 850 deg.) are considered and experimented with.

Some important features of the new stations are: Higher steam pressures and temperatures; reheating the steam to prevent the loss of turbine efficiency due to moisture; heating the feed water with steam extracted from the main unit, using two, three or four bleeding points.

For stations already built it is possible to take advantage of high pressures by installing high-pressure boilers with a small high-pressure turbine for each boiler, the turbine acting simply as a pressure-reducing valve giving out power. Such units are being built in this country for pressures around 1,000 to 1,200 lb. with total temperatures of 700 to 750 deg. In one station the high-pressure turbine discharges the steam into the existing mains at 250 lb., and in another at 350 lb. A considerable gain in economy will result, though it can never be so great as when the whole station is designed for obtaining the highest efficiency.

In connection with the various innovations, two points should be considered. The first is that further extension of the principle of bleeder heating may lead to the general adoption of air heaters, by cutting out other means of recovering flue-gas heat. The second is that where any of these means are used to increase station economy, there is a corresponding increase in the amount of power available, in cases where the power output is now limited by the supply of condensing water.

Expansion Problems Must Be Considered

With increasing pressures and temperatures the design of the turbine must provide for free expansion of the parts that come in contact with high-pressure steam. In new designs careful study has been made of this problem, thereby making the turbines perfectly safe to operate at the present temperatures, and also higher in case they should be called upon to do so. In addition the clearances will be maintained, and also the efficiencies. The attachment of the turbine shell to the front bearing is through two arms directly on the center line. By this arrangement the turbine shell may expand freely in all directions without restraint or any change in alignment. The other end is flexibly attached to the exhaust hood, thereby preventing expansion strains being transmitted to the exhaust casings. Special attention is being given to the design of joints to avoid strains and steam leaks. Steel is now used entirely for diaphragms of turbine casings. A number of plants now under construction will have surface air coolers for the generators, combining fire protection with cleanliness, and also in some cases recovery of part of the generator heat loss.

Practice tends more and more toward the complete use of motor-driven auxiliaries. The tendency is to do away with the house turbine and take current either from the main unit or an independent generator on the main-unit shaft.

In a modern power-producing plant the most essential requirement for success is continuity of service, and unless this can be maintained the efficiency is really of secondary importance.

Difficulties may be experienced with valves and fittings, but these will be overcome by greater attention to the design, and by considering expansion problems and flow requirements.

Predicts 28½ per Cent Plant Efficiency

Some years ago, in discussing the subject of power-plant efficiency with a well-known engineer, it was mentioned that a kilowatt could be produced for as low as 12,000 heat units, representing an over-all efficiency of 28½ per cent, and it is possible that even this figure may be reduced. I think this figure can be some day obtained in practice, but it may be necessary to increase the steam pressure to 1,200 lb. to do it.

By separating the high-pressure portion of the turbine from the low-pressure, high steam pressures in turbines can safely be used, as where the pressures are high the parts are small. Before any further advancement is made, it is natural that the present steps should first be carried out, but they will only lead to further developments.

More Data on Spontaneous Combustion

In line with the modern tendency to use scientific methods in the solution of various practical problems investigations have recently been carried on in the Carnegie Institute of Technology to obtain more definite information in regard to the spontaneous combustion of bituminous coal. The chief information desired was the critical temperatures of various coals under various conditions. The term "critical temperature" refers to a temperature high enough to cause oxidation at such a rapid rate that the coal will automatically heat itself up. The rate of oxidation depends on several factors, among which are the exact composition of the coal, the amount of surface presented, the amount of oxygen present, the temperature, etc. The results of the investigation are given in Bulletin 3 of the Institute. The experiments show that 200-mesh coal has a critical temperature around 340 deg. F., while the critical temperature for 10- to 20-mesh coal is around 450 deg. Coal coarser than ¼ in. gave no critical point within the range of the experiments. These findings are in accordance with the common experience that cases of spontaneous combus-

tion are almost always associated with the presence of fine coal in some part of the pile.

The experiments also show that the coal has a lower critical temperature in moist air than in dry, leading to the conclusion that nothing is to be gained by wetting the coal, except, of course, where it can be stored completely under water.

As far as could be discovered the presence of pyrites, at least in large lumps, does not in any way increase the tendency to spontaneous combustion. In the same way it does no harm to dump fresh coal upon partly oxidized coal provided the latter is not hot at the time. Care should be taken, however, that no accumulation of fine coal occurs at the point where the old coal comes in contact with the new.

The reason for the existence of a critical temperature lies in the fact that when the temperature is increased, the rate of oxidation increases more rapidly than the rate of dissipation of the heat through the coal. When a temperature is reached at which the heat is produced more rapidly than it can be carried away, the temperature jumps automatically, and combustion continues as long as there is air to support it.

Attempts to prevent spontaneous combustion by ventilating the pile are often unsuccessful because the increased oxidation due to the presence of fresh air more than makes up for the heat that is carried away by the air currents. This, of course, is not a universal rule, but corresponds with the condition usually found in practice.

Latest Navy Evaporator Practice

The Navy has recently adopted the low-pressure film-type evaporator as standard practice. An article in the May issue of the *Journal of the American Society of Naval Engineers*, by Commander C. A. Jones and Lieut.-Commander A. M. Charlton, U. S. N., describes in detail the construction of the evaporators, the auxiliary equipment used and the piping systems. It also discusses various operating problems and gives the reasons for changes from previous standard practice in the matter of design and operation. Much of this paper is of interest to engineers concerned with the application of evaporators to stationary installations, and some of these parts are covered briefly in the following abstract.

Until recently the evaporators in the Navy were operated by high-pressure steam. As early as 1912 experiments were made with other types of evaporators, but it was not until 1922 that the type to be described was adopted as standard for naval vessels. This may be briefly described as a low-pressure multiple-effect film-type evaporator based on the patents of S. Morris Lillie, with modifications designed by the Navy Bureau of Engineering.

The two principal reasons for changing to the low-pressure type were the difficulty due to hard scales at high temperatures and the desirability of making use of the large amount of exhaust steam available from marine auxiliaries. The new type of evaporator, in double, triple or quadruple effect, is projected for all ships of the Navy, as funds and time permit.

These evaporators will use low-pressure steam and operate with a 26- to 27-in. vacuum on the last effect. In the film evaporator the tubes are not submerged, but the water drips down over them from a perforated diaphragm above. The raw sea water entering the system is sent through all the effects in series, finally being discharged overboard with a salinity two and one-half times that of normal sea water. A circulating pump on each effect takes water from the bottom of the shell, pumping part of it to the next effect and recirculating the remainder to the perforated plate above the tubes. In falling like rain over the tube nest, part of each drop evaporates, and the rest of the drop washes the salt remaining from the evaporation off the tubes down to the bottom of the shell. The water level in the bottom of the shell is kept just above the lowest row of tubes.

Navy experience shows that this type of evaporator not only permits the use of all available auxiliary exhaust steam, but also obviates deposits of sulphate scale and greatly reduces the formation of carbonate scale. By using a high vacuum the temperature range between the entering steam and the last-effect vapor is large, even with initial pressures below 10 lb. gage.

When rejecting the brine from the last effect with a concentration about two and one-half times normal, the following results may be expected.

Number of Effects	Pounds of Distilled Water per Pound of Steam
Single	0.95
Double	1.60
Triple	2.50
Quadruple	3.30

These results are conditioned, among other things, upon heating the feed water as much as possible with the plant's own available heat. The method of accomplishing this is one of the improvements made by the Navy Department of Engineering. Circulating water for the distilling condensers is taken from the sea, sent to the condensers and discharged overboard, the raw feed being taken from the warm discharge. On its way to the first effect the feed water passes through two vapor heaters located between effects and then through one coil-drain heater on the first effect.

In each effect one tube header is fixed while the other is floating with a special compartment at the end from which the air is drawn through a 1-in. brass pipe to an air pump. The sump at the bottom of each evaporator shell is provided with a horizontal screen, so that pieces of scale will not cause any trouble.

Computations show an important gain in performance by the use of vapor heaters and drain heaters as indicated by the following table for a triple-effect evaporator:

	Water per Lb. of Steam
No heating	1.90
Coil drain heaters only	2.13
Coil drain and vapor heaters	2.50

The gain obtained comes, of course, from the added evaporation in the first effect. The vapor made in the first effect produces nearly twice as much more when it can be sent along to the second and third effects. Without heaters or with coil-drain heaters alone the evaporation in the second effect is greater than in the first and that in the third effect greater than in the second. With all the heaters the greatest evaporation is in the first effect and the least in the third. This change in distribution not only increases the capacity, but also improves the purity of the water by reducing the load on the third effect, and hence its tendency to prime.

British Device To Remove Moisture

In the May issue of the *Power Engineer*, London, there was described an interesting anti-priming steam drier, employing the principle of centrifugal force to separate entrained water from steam. Sectional views of this apparatus, called the Tomkin's Tangential Drier, are shown in Fig. 1. Steam entering at the left passes out radially through the curved veins which give it a whirling motion. The water thus thrown out collects at the bottom of the

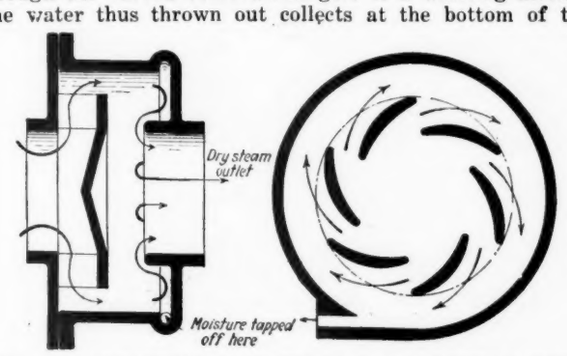


FIG. 1—DIAGRAMMATIC CROSS-SECTION OF STEAM DRIER

cast-iron casing and passes out through a drain hole, the dry steam passing off through the exit at the right.

It is claimed that at a steam velocity, through the blades, of 100 ft. per sec., approximately 90 per cent of the moisture originally in the steam is removed. There are several applications of this apparatus. For example, being small

enough to pass in through a 15x11-in. manhole opening, it may be placed inside of the drum of a boiler just below the discharge nozzle. This application is illustrated by Fig. 2. It is claimed that the fitting of this drier dispenses completely with the necessity for an internal slotted steam

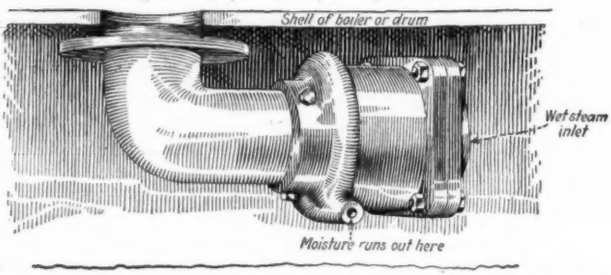


FIG. 2—APPLICATION OF DRIER TO FIRE-TUBE BOILER

pipe, but in cases where this steam pipe is already fitted, it may be, if desired, attached to the spigot of the drier.

The drier may also be applied to the removal of condensation in extended lengths of steam piping.

Experience with Fire-Fighting Equipment for Generators

To assist in the formation of conclusions and recommendations on fighting fires in electric generators, the National Electric Light Association, Electrical Apparatus Committee, sent inquiries to a number of representative companies in all sections of the United States. From a study of this information the committee submits the following conclusions in its 1923 report:

1. Past experience with generator fires has convinced those having that experience, of the necessity of providing some definite permanently installed means of coping with generator fires, supplementing preventive means such as balanced differential relays, periodic insulation tests, etc.

2. Only three of those who have installed on their machines permanent fire-fighting facilities have had experiences in actual fire fighting with this equipment, these fires all being extinguished by the use of steam. Quantitative information on the subject is, therefore, meager.

3. No failures have been reported on water protection equipment permanently installed in generators.

4. Test data on experiments with inert gas (CO_2 in each case) have been published by the Hartford and St. Louis companies, but neither company has had a fire in the generators to which fire-fighting equipment has been applied. Further tests are being made, using both carbon dioxide and nitrogen.

5. On account of small quantitative information, it is not possible to claim actual superiority of one medium over another in extinguishing fires.

Certain modifications were agreed to by all interested in the treatise on extinguishing fires in generating stations prepared by the Fire Underwriters Electrical Bureau. The recommendations of the bureau in which the N.E.L.A. concurs are as follows:

I. All turbo-generators of the horizontal air-cooled type, regardless of size, to be provided with openings in the outer casings, such openings to be covered by quickly removable plates through which quickly accessible hose streams can be injected into the windings.

II. Where space between the outer casings and windings is sufficient, a suitable apparatus should be permanently installed for extinguishment of generator fires. This equipment may be of (1) internal water- or steam-spray type or (2) the type using steam application in air duct below generator; or (3) the type using a satisfactory inert gas. Any type using steam should be designed to avoid high-tension steam impinging directly on the windings. All systems should be connected to a constant source of extinguishing medium arranged for quick application. Care should be taken to prevent water or steam leaking into the generator by installing proper valves and drip.

III. When conditions will permit, a well-installed balanced-relay system be provided which will electrically disconnect the generator from service.

The bureau has given assurance that if such recommendations are adopted non-compliance with them will not affect the insurance rates, but that if such recommendations are put into effect in the majority of systems, a reduction of rates may be possible in the future, due to the smaller number of fires or the resulting decrease in costs to the insurance companies as a result of following these recommendations.

The committee realizes that it will be impossible to follow these recommendations specifically on all types of units, but it strongly recommends their adoption wherever they can be applied.

Control Over Power Rates

BY A. L. H. STREET

The power of a state to regulate the disposal of electric energy transmitted from another state was considered by the North Carolina Supreme Court in the recent case of Corporation Commission vs. Cannon Manufacturing Co., 116 Southeastern Reporter, 178. Dealing particularly with the subject of fixing rates chargeable by a public-service company engaged in furnishing electricity for power purposes, the court first considered the authority of states generally, and then considered the effect on the authority of introduction of energy from another state. On these points the court said:

This power to fix rates that are reasonable and just for public-service companies is conferred in the exercise of the police powers of the state. Having taken from these companies or essentially modified their right of private contract, it is altogether just and proper that they should have such rates and charges fixed as will yield them, as stated, a fair return on their investment, and a sound public policy demands that the rates and charges should also enable them to keep their property and equipment, which they are held to have dedicated in part to public use, in condition to afford adequate, safe and convenient service. When properly established according to the statutory provisions, and after notice and due inquiry, they are co-extensive with the state's jurisdiction and territory and conclusively bind all companies, corporations or persons who, being parties, have been afforded an opportunity to be heard, and are prima facie reasonable and just in all other cases coming within the scope and purview of the inquiry and findings, and it has been directly held that private contracts for a lower rate, though already existent, be to this extent subordinated to the public weal. . . .

While the transportation and sale of electric energy generated in one state and conveyed directly to purchasers in another is undoubtedly interstate commerce, which may be neither prohibited nor taxed nor substantially burdened or interfered with by state regulations, as we understand the record it is the permissible inference that 70 per cent of the power sold to consumers in this state is generated in South Carolina and brought into this state over the transmission lines of the company at a high tension of 80,000 or 100,000 volts, that mingled here with the other 30 per cent of this power, which last is generated in North Carolina, the entire amount at various substations here is "stepped down" or reduced to a commercial voltage and then sold to the consumers from the principal office of the company in the City of Charlotte, N. C., or at the homing place of the consumers in this state. From this statement . . . both the product and the contract concerning them being situate in this state, it would seem that the subject-matter of the controversy is strictly intrastate and may not be subjected to federal control or interference. But it is not now required to make definite ruling on this question, for on the facts as here presented Congress thus far has made no interfering regulations as to the transmission and sale of electricity between the states, and the authorities are at one in holding that though electric power or natural gas may be transported from one state to another, and though interstate commerce may be so far involved in its local sale and distribution that Congress could exert control to the extent required to prevent such commerce from being unduly burdened, in the absence of such action on the part of Congress the local sale and distribution of these products within the several states may be subjected to state regulation in the reasonable exercise of the police power.

News in the Field of Power

Mexican Motive Power Commission Organized

The Mexican Government, according to a report to the Department of Commerce from Trade Commissioner H. B. MacKenzie, has announced the organization of a National Commission of Motive Power (Comision Nacional de Fuerza Motriz), for the organization, development, planning and supervision of commercial exploitation of the natural power resources of the republic. Studies will be made of the legislation in other countries relative to the developments of hydro-electric power and the generation and sale of electrical energy.

The commission's program includes advising the government which bodies of water should be withheld from power exploitation; division of the principal rivers of the country into sections according to their respective possibilities for power or irrigation development; revision of the Federal or local tax laws which may hinder the establishment and operation of hydro-electric plants; study of the advisability of abolishing or modifying the present Federal tax on water concessions; study of the desirability of preserving, restricting or extending the privileges generally granted to power companies; assistance to power companies in obtaining subventions from the government when it is considered that these are for public interest; and the study, in co-operation with local authorities, of the desirability of electrifying certain railroad and street-car lines.

It is planned also to exercise control and supervision over hydro-electric plants already functioning with a view to possibly revising the privileges which authorized the establishment of these plants. Similar plans will probably be developed where the energy is generated from sources other than hydraulic.

Electric Power Plant To Be Built in South Africa

The Victoria Falls & Transvaal Power Co., Ltd., has applied to the Electricity Control Board for an amendment of its license in order to build a new station on the Witbank coal fields, says Consul G. K. Donald, Johannesburg, in a report to the Department of Commerce. The estimated cost of the power station and transmission lines is about $5,000,000.

It has been announced that one of the company's engineers who has just left South Africa for London and the United States will place orders for the equipment needed for this new development. No further information is at present available as to his itinerary or address while in the United States.

One copy each of blueprints, plans and a schedule showing the general scope of this proposed improvement has been sent in to the Bureau of Foreign and Domestic Commerce. The set may be obtained on loan from the Electrical Equipment Division at Washington or through any of the Bureau's District or Co-operative Offices.

Engineers Receive Invitation to Visit Czechoslovakia

The Czechoslovakia Engineers and Architects Association sent an official invitation to the American engineers through the Federated American Engineering Societies to attend its annual meeting in Kosice, Czechoslovakia, during July. The invitation was officially transmitted to the F.A.E.S. through the Minister of Czechoslovakia to the United States and given to Dr. Stepanek of the Czechoslovakia Legation to deliver.

Winners of War Memorial Scholarships Announced

The winners of the Westinghouse War Memorial Scholarship for 1923 have been announced as follows: George Earl Doty, of Pittsburgh, Electrical Engineering, Carnegie Institute of Technology; Lawrence B. Biebel, of Oakmont, Pa., Electrical Engineering, University of Pittsburgh; Paul M. Williams, of Wilkinsburgh, Pa., Electrical Engineering, Carnegie Institute of Technology; Lee P. Doyle, San Francisco, Electrical Engineering, Ohio State University.

Byllesby Buys Wisconsin-Minnesota Light & Power Co.

The control of the Wisconsin-Minnesota Light & Power Co. was purchased recently from the American Public Utilities Co. by H. M. Byllesby & Co., for the purpose of consolidation with the Northern States Power Co. The two systems are connected by transmission lines and their operation will be consolidated immediately.

The Hydro-Electric Power Commission of Canada is making surveys of the water resources in East Peterboro, Ontario. The problem of tapping them, to augment the flow of the Trent through the main power plants at Healey Falls and below Campbellford, is a project that has been discussed for some time, as a development of the Trent power system.

No Anthracite Strike This Year, Says Mr. Hammond

That there will be no strike in the anthracite coal fields this fall, that the price of anthracite to New England consumers will not be above the prices of the last two years and that it will not be necessary for the President to call an extra session of Congress to deal with the situation are the beliefs of John Hays Hammond, chairman of the United States Coal Commission, and of Thomas R. Marshall, a member of the commission.

Both members pointed out that more than 70 per cent of the anthracite was mined by so-called "company" mines and not 8 per cent as had been asserted by Representative Treadway. "These company mines," Mr. Hammond said, "during the last two or three years, during times of great stringency have been charging $8 or $8.50 at the mines, and we do not believe that they will charge more this year, except 15 or 20 cents per ton compensation levied as a tax by the State of Pennsylvania."

Advices from Atlantic City where operators are attempting to negotiate a new wage agreement are not so optimistic about there not being a strike this year as is Mr. Hammond. "We have no knowledge of the source of information of the members of the commission," said S. D. Warriner, chairman of the operators' general committee. "I wish I could share their optimism," said John L. Lewis, president of the United Mine Workers, when shown Hammond-Marshall statements.

Merced River Project Gets 50-Year License

A license for 50 years has been granted the Merced Irrigation District for a power project on the Merced River, near Merced, in Mariposa County, Calif., consisting of a reservoir with 281,000 acre-feet capacity, a concrete dam 320 ft. high, a pressure tunnel 1,800 ft. long, and a power house which will operate under a maximum head of 320 ft. and an average head of 250 ft. The installed capacity of the plant is to be 25,000 kw.

The dam and reservoir will be constructed primarily for irrigation and storage, the water being released through a system of canals to the 200,000 acres of land included in the irrigation district. The construction of the reservoir will necessitate relocation of 17½ miles of the Yosemite Valley Railroad at a cost of about $2,500,000. The district has entered into a 20-year contract to sell practically all the power

to be generated at the plant to the San Joaquin Light & Power Corp., reserving only the small amount needed around the plant and storage works. This is one of the most important storage and power developments yet undertaken by an irrigation district in this country. The total eventual investment is estimated to be $13,478,000.

Applications for Tennessee River Power in Conflict

That there is quite a controversy on for the control of the water power resources of the Upper Tennessee is evidenced further by the filing with the Federal Water Power Commission of an application for a preliminary permit, by the Tennessee Electric Power Co., covering three large projects on the Clinch and Powell Rivers. The application is in conflict with two applications previously filed. One is that of the Knoxville Power & Light Co., a subsidiary of the Electric Bond & Share Co. The other was filed by the Tennessee Hydo-electric Co., which was backed by Pittsburgh interests.

The project of the Tennessee Electric Co. is practically identical with that contemplated by the Knoxville Power & Light Co. One of the three developments proposed is on the Clinch River below its junction with the Powell. The plan is to erect a dam 175 ft. high at that point, so as to create a pool 42 miles long with a 40 ft. drawdown, to make 1,000,000 acre-feet of live storage, equalizing the flow of the river and obtaining a power capacity of 100,000 hp. The second development, consisting of a dam 160 ft. high, is planned for the head of the pool created by the first dam, and will be near the railroad station of Cheat River. It is expected to develop 50,000 h.p. at this point. The third development is to be on the Powell at the head of the pool and consists of a dam 180 ft. high in that stream, near the town of Combs, and it is expected to develop 27,000 hp. here, making a total of 177,000 hp. at the three sites.

The Tennessee Electric Power Co., of Chattanooga, serves a large territory between Chattanooga and Bristol and Chattanooga and Nashville. It has an existing development at Hales Bar on the Tennessee, another on the Ocoee and another at Great Falls on Caney Fork. This gives the company a total capacity of 108,000 hp. at its water-power plants. In addition it operates three steam plants, with a total capacity of 59,000 hp.

The Tennessee company reports that its load is growing at such a rate that it will require 40,000 hp. more within the next four years. If these requirements cannot be met from water power, the company has announced its intention to install further steam plants. The Federal Power Commission is anxious to prevent a situation that will result in the construction of steam plants in a region of abundant water power. Owing to the magnitude of the power involved and the determination of the interests concerned, the Commission's handling of this matter will be watched with more than ordinary interest. Incidentally, it may be stated that the Federal Power Commission is much concerned in securing maximum utilization. Since this can be accomplished best by confining operations on a single stream to one company, it is anticipated that there will be no effort to divide the sites among the contending applicants.

Coming Conventions

American Chemical Society, Dr. Charles L. Parsons, 1709 G St. N. W., Washington, D. C. Convention at Milwaukee, Wis., Sept. 10-14.

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

American Institute of Mining and Metallurgical Engineers; F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at Ontario, Quebec, Canada, Aug. 20-31.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Illuminating Engineering Society, H. E. Mahan, Schenectady, N. Y. Convention at Fort William Henry Hotel, Lake George, N. Y., Sept. 24-28.

International Union of Steam and Operating Engineers; Dave Evans, 6334, Yale Ave., Chicago, Ill. Annual convention at Detroit, Sept. 10-15.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 914-25 East Jackson Blvd., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Pennsylvania**, at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York**, at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y. **Minnesota**, at Duluth, Aug. 8-10; C. A. Nelson, 800 22d Rve. N. E., Minneapolis.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

The New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

Universal Craftsman Council of Engineers; John F. Amos, P. O. Box 299, Rochester, N. Y. Convention at Powers House, Rochester, N. Y., Aug. 7-11.

New Publications

Engineering Handbook; Pumping Machinery, Air Compressors and Condensers. Compiled by E. P. Ordway, M.E. Published by the Union Steam Pump Co., Battle Creek, Mich., third edition; 447 pages.

This convenient hand book has information on the proper selection, installation and operation of pumping machinery, air compressors and condensers. Of a handy size, with clear type and a good index, and with innumerable tables of data and explanatory illustrations, this handbook should prove useful for quick and ready reference on the subjects covered.

Combustibles Liquides. La Société de Chimie Industrielle, 49 rue des Mathurins, Paris. French. Paper, 900 pages, 8½x10¾-in. Price, $2.50.

La Société de Chimie Industrielle has recently published the transactions of the congrés which was held in connection with the Exposition Internationale des Combustibles Liquides at the Esplanade des Invalides in Paris, October 4-15, 1922. The papers, communications and records of conferences of this congress on liquid fuels should prove useful to seekers after information on fuel oils. The subject has been covered quite thoroughly and is arranged in the volume as follows: Minutes of the congress; report of conferences; papers on gasoline, shales, lignites and peats, tars and benzols, alcohol, vegetable oils.

Thirty Year Review of the General Electric Company. By Owen D. Young and Gerard Swope, for the Board of Directors of the General Electric Co., Schenectady, N. Y. Paper, 6x9 inches.

This small booklet, gotten out by the General Electric Company, traces the history and development of the electrical arc, which grew out of the early pioneering work of the company and of the Thomson-Houston Electric Co., and the astonishing growth of the business, the rapid increase in the size of generating units, steam turbines and the ever widening application of electric power. It is adequately illustrated and, while intended for the stockholders, is yet of interest to everyone interested in electrical accomplishments and possibilities.

The Industrial Utility of Public Water Supplies in the United States by W. D. Collins is Water-Supply Paper No. 496 of the United States Geological Survey. This report deals with the important subject of hardness or mineral content of water furnished by public water

works and gives analyses and descriptions of the water supplied by them to 307 cities in the United States and discusses the softening treatment of the water for boiler and other uses. A map showing the distribution of hardness of waters by states is included. This paper can be purchased from the Superintendent of Public Documents, Washington, D. C., for 10 cents.

"Some Practical Aspects of Fuel Economy," by Carl W. Mitman, is No. 1 of Vol. 76 of the Smithsonian Miscellaneous Collection, published by the Smithsonian Institution, Washington, D. C.

Personal Mention

W. H. Patchell, of London, will sail for his annual visit to the United States on August 9. He is to be the next president of the Institution of Mechanical Engineers of Great Britain.

Frank A. Leach, Jr., former manager of the East Bay division of the Pacific Gas & Electric Co., and more recently vice-president in charge of public relations and service, has been named vice-president and general manager of the company to take the place of John A. Britton.

Harold A. Thomas, for the last 13 years a member of the staff at Rose Polytechnic Institute, Terre Haute, Ind., has been appointed to the faculty of Carnegie Institute of Technology, Pittsburgh, Pa., as professor of theoretical hydraulics and of hydraulic and sanitary engineering.

Joseph J. Nelis has been appointed chairman of the Meetings Committee of the Metropolitan Section of the A.S.M.E. and is eager that suggestions, from the membership of the section, of topics that might be interesting be sent him in care of the Power Specialty Co., 111 Broadway, New York City.

Professor A. L. Lomchakoff, of the Technical University of Prague, and **Stanislav Spacek**, Technical Attache of the Czechoslovakia Legation, have been visiting New York City seeking information regarding fuel, power and gas production and the development and use of pulverized fuel in the United States.

Frank C. Reeder, who has represented the Hoffman Specialty Co. in the Southern States for the last four years, has resigned to take the position of factory representative with the Fulton Company, of Knoxville, Tenn., with which he was identified during its early history and prior to his connection with the Hoffman Specialty Co.

Business Notes

The Westinghouse Electric & Mfg. Co., Foreman's Association, South Philadelphia Works, held its fifth annual picnic at Tinicum Woods on Saturday, June 30, 1923. Games and sports of all kinds were scheduled for the entire day as well as dancing and music for the afternoon and evening.

The Elliott Co., Pittsburgh, Pa., manufacturers of power-plant specialties, announces the following changes in its sales organization: M. C. Sickels, formerly district manager of the Cleveland office, is now in charge of the Chicago office; C. H. Sweet, who has been connected with the Philadelphia office for a number of years, becomes sales manager of the Cleveland office.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	July 16, 1923	July 23, 1923
Pool 1,	New York	$3.25@3.75	$3.25@3.50
Smokeless,	Columbus	3.00@3.50	3.00@3.50
Clearfield,	Boston	2.00@2.75	2.00@2.75
Somerset,	Boston	2.25@3.00	2.25@3.00
Kanawha,	Columbus	1.75@2.00	1.75@2.00
Hocking,	Columbus	1.75@2.00	1.75@2.00
Pittsburgh No. 8	Cleveland	1.90@2.10	1.90@2.00
Franklin, Ill.	Chicago	2.75@3.25	2.75@3.25
Central, Ill.	Chicago	2.00@2.25	2.00@2.25
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.50@1.90	1.60@1.85
S. E. Ky.,	Louisville	1.75@2.25	1.50@2.00
Big Seam,	Birmingham	1.75@2.15	1.75@2.15

FUEL OIL

New York—July 26, light oil, tank car lots, 28@34 deg. Baumé, 4c. per gal.; 36@40 deg. 4¼c. per gal., f.o.b. Bayonne, N. J.

Chicago—July 14, 24@26 deg. Baumé, $1.97 per bbl.; 32@36 deg., $2.27 per bbl., tank cars.

St. Louis—July 17, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.80 per bbl.; 26@28 deg.; $1.85 per bbl.; 28@30 deg., $1.90 per bbl.; 32@36 deg.; gas oil, 4½c. per gal.; 36@40 deg., distillate, 5c. per gal.

Pittsburgh—July 18, f.o.b. local refinery, 30@34 deg., fuel oil, 4⅞c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.; 34 deg., neutral, 7¼c. per gal.

Dallas—July 21, f.o.b. local refinery, 26@30 deg., $1.39 per bbl.

Cincinnati—July 25, tank car lots f.o.b. local refinery, 26@30 deg. Baumé, 4¾c. per gal.; 30@32 deg., 5c. per gal.; 38@42 deg., distillate, 6¼c. per gal.

New Plant Construction

PROPOSED WORK

Ark., Forrest City—O. B. Rollwage, Secy., Forrest City Special Improvement Dist., will receive bids until Aug. 6, for the construction of a power plant, including 2 ton traveling crane. Estimated cost $25,000. F. J. Herring, Engr.

Ark., Marianna — The city is having plans prepared for the reconstruction of the pumping plant, mains, etc. Estimated cost $120,000. T. H. Allen, 510 Bank of Commerce, Memphis, Tenn., Engr.

Calif., Long Beach—The Bank of Italy, 660 South Bway., Los Angeles, is having plans prepared for the construction of a 12 story, 80 x 125 ft. bank building on 3rd St. and American Ave. Estimated cost $1,000,000. Walker & Eisen, Pacific Finance Bldg., Los Angeles, Archts. Equipment detail not reported.

Calif., Ravenswood (Redwood City P. O.)—The city and county of San Francisco are having plans prepared for the installation of a pumping plant here (to be portion of Hetch Hetchy project). Estimated cost $17,000. M. M. O'Shaughnessy, Ch. Engr.

Calif., Watts—The Conservative Water Co. plans to lay approximately 10 mi. c.i. and screw pipe and install new pumps and meters.

Colo., Denver—The city plans to install the following equipment to improve its water system: one 10,000,000 gal. per day steam turbine driven centrifugal pump at the Capital Hill station, $14,210; one 8,000,000 gal. per day electric motor driven centrifugal pump at Ashland Ave. pumping station, $4,820; one 4,000,000 gal. per day electric motor driven centrifugal pump at University Park pumping station, $2,945.

Conn., Hartford—The Imperial Dying & Cleaning Co., 454 Park St., is in the market for a new high pressure horizontal boiler.

Conn., Southington—The Walker Stewart Foundry Co., Summer St., plans to build a new foundry and is in the market for equipment, including furnaces, blowers, ventilating and conveying systems, etc. Estimated cost between $50,000 and $60,000.

Fla., Indian River City — The Indian River City Town Site Corp. is having plans prepared for the construction of a 200 room hotel. Estimated cost $600,000. Marsh & Saxelbye, 415 West Bldg., Jacksonville, Archts. Equipment detail not reported.

Ill., Chicago—The Bd. Educ., 640 South Clark St., is having plans prepared for the construction of a 4 story high school, including steam heating system, on Wilson, Leland, Kimball and St. Louis Sts. Estimated cost $4,000,000. J. C. Christensen, 640 South Clark St., Archt.

La., West Monroe — The city, E. F. Thompson, Secy.-Treas., will receive bids until Aug. 2 for the construction of a sewer system and pumping station. Estimated cost $87,000. R. S. Reynolds, Engr.

Minn., Duluth—The Duluth Phoenix Utilities Co., Lyceum Bldg., acting for the American Power & Light Co., has purchased the power plant of the St. Louis Power & Improvement Corp. Purchase includes hydro-electric plant at Knife Falls, Stevens plant at Scanlon, and the plant of General Light & Power Co., serving Cloquet and towns north and south. Present power production of St. Louis River will be increased from 80,000 to 95,000 hp.

Mo., Burlington Junction—The city plans election soon to vote $50,000 bonds for the construction of a pumping plant, distribution system, etc. E. T. Archer & Co., New England Bldg., Kansas City, Engrs.

Mo., Holden — The city plans election about Sept. 20 to vote $75,000 bonds for the construction of a pumping plant, reservoir, distribution system, etc. The Benham Engineering Co., 512 Gumble Bldg., Kansas City, Engrs.

Mo., St. Louis—The Central Y. M. C. A., c/o B. Moser, 901 Carr St., is having preliminary plans prepared for the construction of a 10 story club, office and hotel building. Estimated cost $1,000,000. Private plans.

Mo., St. Louis—The Southern Realty & Investment Co., Central Natl. Bank Bldg., plans the construction of a 12 story, 79 x 121 ft. office building on 6th St. Estimated cost $1,000,000.

N. H., Marlboro—The Ashuelot Gas & Electric Co., Concord, plans the construction of a power house to contain hydraulic turbines, concrete arch dam, 53 x 220 ft. and 40 in. penstock connecting the two. Estimated cost $100,000.

N. Y., Troy — The Troy Masonic Hall Assn. plans the construction of a 7 story, 190 x 225 ft. temple, including an auditorium, on 8th St. Estimated cost $650,000.

N. C., Greensboro—The Building Committee of the Agricultural & Technical College will receive bids until Aug. 1, for furnishing and installing plumbing, heating and electrical equipment in new dormitory and refectory buildings.

N. C., High Point—The High Point Furniture Co., M. J. Wrenn, Prop., is in the market for generator, 225 kva., a.c., 3 phase, 60 cycle, 220 volts, 514 r.p.m. with sliding base, driving pulley and pulley for driving exciter, 7-1.2 kw. generator exciter, and switchboard panel, slate 24 in. wide, 60 in. high, 1½ in. thick (this is double throw switch arrangement); 30 hp. motor, 3 phase, 60 cycle, 220 volts; two 20 hp. motors, 3 phase, 60 cycle, 220 volts; five motors, 3 phase, 60 cycle, 220 volts; four 10 hp. motors, 3 phase, 60 cycle, 220 volts; ten 5 hp. motors, 3 phase, 60 cycle, 220 volts; two 5 hp. motors, 3 phase, 60 cycle, 220 volts (vertical); one 2 hp. motor, 3 phase, 60 cycle, 220 volts. (vertical). New outfits are in good used condition.

N. C., Salisbury—The Graf Davis Collet Co. is in the market for a 150 hp. steam boiler.

N. C., Sylva — The Cullohwee Normal School plans the installation of boilers, engines, generators, switch board, pipe tunnels and water facilities. H. A. Underwood, Raleigh, Engr.

Ohio, Cleveland—The Brown Fence & Wire Co., J. Brown, Pres., 6532 Junita Ave., is in the market for a 150 hp. steam boiler.

Ohio, Cleveland—The city will receive bids until Aug. 3 for furnishing and erecting water tube boiler and radial brick chimney at Woodland Ave. bathhouse.

Ohio, Cleveland—The Cleveland Wrought Products Co., 58th St. and Denison Ave., is in the market for two 100 hp. boilers.

Ohio, Sandusky—The Sandusky Constr. Co., soon to be incorporated, C. B. Wilcox, 621 Wayne St., Pres., is having plans prepared for the construction of a 6 story hotel. Estimated cost $250,000. J. M. Graham & Co., Cleveland, Archts. Equipment detail not reported.

Ohio, Toronto—The Ohio River Edison Co., Broadway, New York, is having plans prepared for the construction of a 200 x 200 ft. power plant, (first unit) capacity 75,000 kva. Estimated cost $1,000,000. Additional units later, 300,000 kva. capacity. Total estimated cost $8,000,000. Stevens & Wood, Inc., 120 Bway., New York, Engrs.

Okla., Cushing—The city is having plans prepared for the construction of a reservoir, pipe lines, purification plant and pumping machinery. Estimated cost $250,000. Black & Veatch, Mutual Bldg., Kansas City, Mo., Engrs.

Okla., Stillwater—The city will hold election in August to vote 25,000 bonds for the construction of a new earth dam, spillway, pipe lines, pumping station and machinery. V. V. Long & Co., 1300 Colcord St., Oklahoma City, Engr.

Ore., Jennings Lodge — H. L. Gilbert, Engr., Couch Bldg., Portland, will receive bids about Aug. 15, for the construction of a waterworks system, including a 600,000 gal. concrete reservoir, 150 g.p.m. electrically driven pump, etc., for the Oak Lodge Water Dist. Estimated cost $200,000.

Ore., Oakridge—G. H. Kelly, Spaulding Bldg., Portland, plans to establish a new town about 4 mi. from here. Project includes the construction of an electrically driven 200,000 ft. b. m. per day capacity sawmill, planing mill, dry kilns, power dam, etc. Estimated cost $2,000,000. W. J. Morris, Spaulding Bldg., Portland, Engr.

Pa., Pittsburgh—The Bd. Educ., Fulton Bldg., is having plans prepared for the construction of a 3 story high school addition on Ruth St. Estimated cost $1,000,000. Alden & Harlow, Farmers Bank Bldg., Archts. Equipment detail not reported.

Pa., Pittsburgh—The Press Publishing Co., 220 Oliver Ave., is having plans prepared for the construction of a 6 story newspaper publishing plant on Bigelow Blvd. and 7th Ave. Estimated cost $700,000. Hunting Davis Co., Century Bldg., Archts. Equipment detail not reported.

Pa., Scranton—W. G. Watkins, County Controller, Court House, will receive bids until Aug. 6, for the construction of an addition to county tuberculosis hospital at West Mountain. Estimated cost $300,000. D. H. Morgan, Connelly Bldg., Archt. Equipment detail not reported.

S. C., Andrews—The city will receive bids until Aug. 22 for water and sewerage improvements, including electrically driven pumping machinery, reservoir, filter and transmission lines. Estimated cost for waterworks $70,000, sewers $30,000. Ryan Eng. Co., Columbia, Engrs.

S. D., Flandreau—The city will receive bids until Aug. 6, for waterworks improvements, including concrete well and brick pump house of 400,000 gal. capacity per day. Estimated cost $20,000. Chenoweth, Kennedy & Rettinghouse, Sioux Falls, Engrs. Noted July 24.

Tenn., Nashville—The Bd. Public Works, G. Reyer, Supt. Water Works, plans the installation of a new filter plant unit, force main from reservoir to pumping station and new 600 hp. steam boiler.

Tex., Ballinger — Coke Runnels Water Improvement Dist. No. 1 plans election in August to vote $4,500,000 bonds for the construction of a dam, 2,000 ft. long, 100 ft. high, to irrigate 200,000 acres of land. C. C. Holder, Bronte, Engr.

Tex., Rogers—F. Leahy, (contractor), is in the market for a Fairbanks hopper, sud scales, Ford boiler and steam pump.

Vt., Castelton—R. R. McRae will soon be in the market for ice manufacturing machinery, conveyors, cold storage machinery, etc., for new plant.

Va., Norfolk—The Taylor Parker Co., Water St. and Commerce Place, is in the market for engines from 50 to 150 hp. and boilers of the same power.

W. Va., Cabin Creek Jct.—The Virginia Power Co., Union Trust Bldg., Charleston, is having plans prepared for the construction of a coal handling plant, extension of power house and dredging for harbor. L. Doherty Co., 60 Wall St., New York, Engr.

Wis., Madison — The Chicago & Northwestern Ry., B. R. Kulp, Dist. Engr., 201 South Blair St., is having plans prepared for the construction of a 60 x 110 ft. coaling station, including coal handling machinery, cranes, conveyors, etc. Estimated cost $75,000. Private plans.

Wis., Madison—The city, c/o C. M. Boley, City Hall, is having plans prepared for the construction of a new steam heating plant at the City Almshouse, including boilers, radiation and regulation equipment. R. R. John, City Hall, Engr.

Wis., Madison—R. A. Phillips, Engr., 315 Beaver Bldg., is receiving bids for the construction of a new steam heating plant for St. Johns Lutheran Church, 316 East Washington Ave. Noted May 22.

Wis., Menominee—The Bd. Normal Regents, W. J. Kettle, Secy., Capitol, Madison, plans the construction of a power plant and switchboard at Stout Institute, here Estimated cost $74,460.

Wis., Milwaukee—The Pittsburgh Plate Glass Co., 213 Lake St., and Cahill & Douglass, Engrs., 213 West Water St., are receiving bids for the construction of a 2 story, 60 x 80 ft. power house. Noted Feb. 27.

Wis., Stevens Point—The Stevens Point Brick Co., 426 Normal Ave., plans to rebuild its plant and is in the market for brickmaking machinery, conveyors and boilers.

N. S., Montague — The Clark Gold Mines Corp., Ltd., E. S. Romilly Smith, Genl. Mgr., is in the market for mining and testing machinery (changing from steam to electric equipment).

Ont., Haileybury—The town council, H. A. Day, clk., plans to install pumping equipment, including 3 stage motor driven centrifugal pumps, for fire protection. Estimated cost $20,000.

Ont., Oshawa — The Imperial Oil Co., Ltd., Imperial Oil Bldg., Toronto, is having plans prepared for the construction of steel storage oil tanks and pumps. Estimated cost $40,000. Private plans.

Ont., Toronto—J. Inglis & Co., Ltd., 14 Strachan Ave., will soon be in the market for electric traveling crane, sand mixing machine, etc.

Que., Three Rivers—R. Morrissette is in the market for one centrifugal pump, 2½ in. discharge, capacity 125 g.p.m. and 1 electric motor, 5 hp. automatically controlled by the level in the reservoir, 250 ft. from pumping plant.

CONTRACTS AWARDED

Fla., Sarasota—A. McAnsh, 2088 South La Salle St., Chicago, Ill., awarded the contract for the construction of a hotel on Central Ave., to W. R. Carman Co. Estimated cost $350,000. Equipment detail not reported. Noted Apr. 24.

Mass., Boston—St. Elizabeth's Hospital, 731 Cambridge St., Brighton, awarded the contract for the construction of a 4 story, 100 x 150 ft. hospital in Brighton District, to M. W. Ryan, 2 Central Sq., Cambridge. $250,000. Equipment detail not reported.

Mass., Worcester—The State Mutual Life Assurance Co., 340 Main St., awarded the contract for the construction of a 4 story, 112 x 188 ft. office building, including steam heating system, on Maple St., to the E. J. Cross Co., 82 Foster St. Estimated cost $500,000. Lighting system awarded to the Economy Electric Co., 22 Foster St.

Mich., Lincoln Park (Wyandotte P. O.)—The village awarded the contract for the construction of a pump house and installing a 500 gal. capacity, electrically driven centrifugal pump, to the Oakwood Constr. Co., Oakwood Ave., Detroit, $15,000.

Mo., Kirksville—The city awarded the contract for filter equipment to E. W. Bachrach & Co., 616 Rialto Bldg., Kansas City, $7,667.

Mo., St. Louis—The York Rite Temple Assn. awarded the contract for the construction of a 160 x 300 ft. temple on Lindell Blvd., to the Westlake Const. Co., Railway Exchange Bldg. Estimated cost $3,000,000. Equipment detail not reported. Noted May 30, 1922.

N. D., Bismarck—The Holy Ghost Cathedral, c/o V. Wehrle, awarded the contract for the construction of a 110 x 320 ft. cathedral, including steam heating system, to W. H. Arrell, 711 21st Ave., N., Minneapolis, Minn. Cost about $500,000.

N. D., Casselton—The city, C. D. Smith, Clk., awarded the contract for waterworks improvements and sewer system to the Haggart Constr. Co., Fargo, N. D., $55,669. Noted Feb. 27.

Ohio, Cleveland—S. E. Dettlebach, Williamson Bldg., awarded the contract for the construction of a 16 story, 132 x 200 ft. hotel on East 12th St. and Walnut Ave., to the Crafts Constr. Co., Sloan Bldg., Cleveland. Estimated cost $3,000,000. Steam heating system will be installed.

Ohio, Cleveland — The Fairview Park Hospital Assn. 3305 Franklin Ave. F. H. Diehm Supt. awarded the contract for the construction of a 2 story 45 x 47 ft. nurses' home boiler house and laundry to the C. N. Griffen Constr. Co. 5511 Euclid Ave. Estimated cost $150,000. Noted May 1.

Ohio, Cleveland — The Larkspur Apartment Co., c/o G. A. Grieble, Archt., Sloan Bldg., awarded the contract for the construction of an 8 story, 50 x 142 ft. apartment house at 2338 Euclid Ave., to the Crafts Constr. Co., Sloan Bldg. Estimated cost $500,000. Steam heating system will be installed.

Tenn., Memphis—The Columbian Mutual Life Assurance Society awarded the general contract for the construction of a 22 story, office building on North Main and East Court Sts., to Keely Bros. Constr. Co., East St. Louis St., St. Louis, Mo. Estimated cost $1,000,000. Equipment detail not reported. Noted Dec. 19, 1922.

Tex., Dallas—E. D. Gonzales, 3029 Bryan St., awarded the contract for the construction of a 9 story, 90 x 103 ft. hotel on Harwood and Jackson Sts., to the Hughes O'Rourke Constr. Co., Praetorian Bldg., $311,000. Equipment detail not reported.

Wis. Milwaukee — The Central Bd. of Purchases awarded the contract for two 100 kw. uniflo engines and generators for Riverside pumping station to Ames Iron Wks. Oswego N. Y. Estimated cost $16-250. Noted July 10.

Wis., Milwaukee — The Milwaukee Elec-Ry. & Light Co., 2nd and Sycamore Sts., awarded the contract for the construction of a sub-station on 36th and Wells Sts., to the Dahlman Constr. Co., 456 Bway. Estimated cost $25,000. Equipment to the General Electric Co., 2nd and Sycamore Sts.

Wis., Park Falls—The city, J. J. Steuber, Clk., awarded the contract for the construction of a water supply system, including test wells and pumping equipment, to the Layne & Bowler Co., 37 West Van Buren St., Chicago, Ill., $18,000.

Wis., Wisconsin Rapids — The Bd. Educ., c/o Clerk, City Hall, awarded the contract for the installation of a steam heating plant in Lincoln High School, to the Grand Rapids Plumbing & Heating Co., Wisconsin Rapids. Noted July 3.

Ont., Kitchener—The Sisters of Mount St. Joseph, Hamilton, awarded the contract for the construction of a 3 story, 50 x 180 ft. building with two 48 x 102 ft. wings, to W. M. Sutherland Constr. Co., 43 Adelaide St. W., Toronto. Estimated cost $445,000. Watt & Blackwell, Archts., Bank of Toronto Bldg., London, are receiving bids on complete modern hospital and steam heating equipment. Noted June 26.

Que., Montreal — The Montreal Light, Heat & Power Co., Craig St., awarded the contract for the construction of a 2 story, 55 x 67 ft. electric sub-station on Beaumont St., to W. Irving, 26 Stanley St., $43,000.